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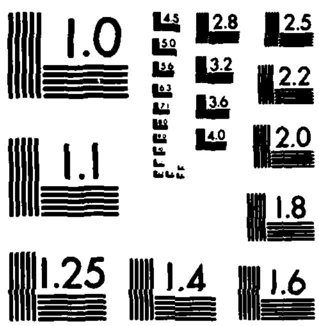
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OPNAVNOTE 3905

THE UTILIZATION OF NAVY PEOPLE-RELATED RDT&E

6th ANNUAL REPORT

FISCAL YEAR 1982

contract N66001-81-C-0432

ASSEMBLED BY:

NAVY PERSONNEL RESEARCH AND DEVELOPMENT CENTER
SAN DIEGO, CALIFORNIA 92152

JUNE 1983

APPROVED FOR PUBLIC RELEASE
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DEPARTMENT OF THE NAVY
OFFICE OF THE CHIEF OF NAVAL OPERATIONS
WASHINGTON, DC 20350

Canc: Aug 1984
IN REPLY REFER TO
OPNAVNOTE 3905
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OPNAV NOTICE 3905

From: Chief of Naval Operations

Subj: Sixth Annual Report on the Utilization of People-Related RDT&E

Ref: (a) UNDSECNAV Memo of 26 Sept 1978, Subj: Navy Manpower, Personnel and Training Research, Development and Studies (NOTAL)
(b) General Accounting Office Report FPCD 77-43 of 22 Apr 1977 (NOTAL)

Encl: (1) Sixth Annual Report on the Utilization of People-Related Navy RDT&E

Indef for #6

1. Purpose. To promulgate the Sixth Annual Report on the Utilization of People-Related Navy RDT&E (enclosure (1)) and forward it for information and appropriate action. This report contains examples of the use of this R&D. It is a principal means whereby the Navy complies with the recommendations of references (a) and (b) that utilization be encouraged, that communication between the user and researcher be improved, and that utilization of this R&D be tracked.

2. Action

a. Addressees are requested to review enclosure (1) to identify any of the following:

(1) RDT&E that they have used but has not been reported in enclosure (1) or any of its predecessors.

(2) Completed RDT&E that might be useful in activities under their cognizance.

(3) RDT&E near completion that they should monitor to use when completed.

b. Any previously unreported instances of utilization should be reported to:

Commanding Officer
Navy Personnel Research and Development Center
Code 303
San Diego, CA 92125

c. Addressees desiring assistance in using completed RDT&E or in monitoring potentially useful R&D should direct inquiries to the appropriate R&D organizations as listed in enclosure (1).

d. Request appropriate action to be completed by 31 May 1984. Negative reports are not required.

3. Report. Symbol OPNAV 3905-1 has been assigned to the requirement contained in paragraph 2. This information will be requested yearly by notice.

J. T. PARKER, JR.
Deputy Director
Research, Development, Test and Evaluation

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	26V	(Landing Force Training Command)
	26KK2	(Petroleum Training Unit PAC)
	26DDD	(Fleet Combat Systems Training Unit)

INDEX FOR #6

OPNAVNOTE 3905

THE 6th ANNUAL REPORT

OF

THE UTILIZATION OF NAVY PEOPLE-RELATED RDT&E

INDEX FOR #6

Enclosure (1)

FOREWORD

This is the sixth annual report on people-related research, development, test, and evaluation (RDT&E) in the Navy. Since the first report in the series was published in 1978, a considerable number of accomplishments in the people-related areas of manpower, personnel, training and human factors engineering have been described. These have included large-scale, multi-year programs as well as smaller project efforts in key areas. An index to projects reported previously is included in this report.

The primary emphases in these reports have been on the utilization of RDT&E products by Navy operational communities, and on the benefits in both cost and operational effectiveness resulting therefrom. An additional focus has been on the significant advances in the state of the art that many of these RDT&E efforts have contributed. It is possible for one who reads each of the utilization reports closely to note instances in which earlier efforts have laid the groundwork for later, related developments. This building process is crucial to the people-related RDT&E program, as it is in any scientific or technical endeavor.

The projects described here represent only a fraction of the overall program of people-related RDT&E being conducted at centers and laboratories throughout the Navy. The efforts reported are not unique; they are instead representative of people-related RDT&E products utilized in FY 1982 or being prepared for near-term implementation.

This report was compiled by the Navy Personnel Research and Development Center, San Diego, CA. The manuscript was prepared by Resource Consultants, Inc., of McLean, VA, under Contract N66001-81-C-0432. Appreciation is expressed to participating personnel at each contributing command, and also to those individuals who contributed documentation, clarification, and sound advice while the report was in preparation. Inquiries and comments from sponsoring and user commands are encouraged.

INDEX FOR #6

TABLE OF CONTENTS

NPRDC PARTICIPATION

INDEX FOR #6

INTRODUCTION

THE SETTING

In his statement before the Subcommittee on Military Personnel and Compensation of the Committee on Armed Services, House of Representatives, in March 1983, the Principal Deputy Assistant Secretary of the Navy (Manpower and Reserve Affairs) summarized:

"The United States is a maritime nation that will forever depend on the free use of the seas to participate in the world trade, to provide access to scarce strategic resources, and to support the global alliances that ensure our national security. Guaranteeing that freedom of the seas requires the large, proficient, technologically advanced forces that, with the support of the Congress and the American people, we are building. To man that force with the proper mix of skilled, experienced officers and enlisted personnel is our overriding challenge during the 1980s."

At the present time, both the Navy and the Marine Corps are achieving a high measure of success in recruiting and retaining the personnel required. They anticipate continuing to do so even though the size of the force will expand by approximately 50,000 active duty uniformed personnel in order to man a 600 ship force by 1990. Nonetheless, there will continue to be a need to adjust and improve our use of available resources, so that we are able to provide the best defense possible with the resources provided.

THE TRAINING AND PERSONNEL SYSTEMS TECHNOLOGY PROGRAM

Research and development is the enterprise in which we engage as a means to improve the use of our resources in meeting future needs. In the case of the men and women, civilian, military and Reserve, who people the Navy, the research and development program within the Department of Defense is titled the "Training and Personnel Systems Technology (TPST) Program." The totality of the TPST Program in all the services approximates slightly more than 1 percent of the Defense research and development program.

The TPST Program develops and initiates implementation of new techniques in four categories related to the effective use of our human resources. These four categories, which form the organizational structure of this report, are:

- Manpower and Personnel
- Education and Training
- Human Factors Engineering
- Simulation and Training Devices.

With changes in the policy and economic environments, in the structure of the operational forces, and in the demographic and sociological makeup of the nation as a whole, particular areas of effort at times assume greater relative importance. The emphases in TPST during the period covered by this report have been on efforts to:

- Maintain performance levels
- Predict the effectiveness of personnel
- Develop lower cost training that is more effective and more available
- Build the technology base to meet future needs
- Make greater use of available microprocessor technology
- Enhance the impact of manpower, personnel and training in the weapon system acquisition cycle.

THE PURPOSE OF THE UTILIZATION REPORT

This report is one means by which the Navy communicates its success in developing and implementing specific solutions to problems the service faces in the acquisition, training, utilization, and management of personnel. The report is intended to increase the utilization of newly developed training and personnel systems technology, and also to foster greater Navy-wide and interservice coordination of efforts in people-related RDT&E. In each project summary, emphasis is placed on the operational need that generated the effort, the manner in which the research products or results were (or will be) utilized, and the actual or potential "payoff." Each summary also includes a section which identifies the performing activity, sources of funding for the project, and sources of additional information. A diagram is provided illustrating the evolution of the effort through research, development and implementation. The successive levels are:

- 6.1: Research—Scientific study and experimentation directed toward increasing knowledge in fields related to long-term national security needs.

- 6.2: Exploratory Development—Efforts directed toward the solution of specific military problems short of major development.
- 6.3: Advanced Development—Development of systems or system components for experimental or operational test. A primary objective is proof of design concepts.
- 6.4: Engineering Development—Design, fabrication, and testing of full-scale systems for operational application.
- 6.5: Management and Support—Effort directed toward support of installations or operations required for general research and development use.

EMPHASES IN THIS REPORT

The Utilization Report for FY82 focuses on work which has been completed recently and which emphasized improvements such as:

- Improving the forecast of long-range manpower requirements
- Managing the officer personnel force more effectively
- Allocating military pay in the most effective manner
- Identifying people who deliberately fail selection tests
- Reducing Marine Corps first-term attrition
- Planning for research to support the Navy Family Program
- Providing a better flow of information about TPST research and development
- Improving the reading skills of Navy personnel
- Providing systematic on-the-job training on propulsion systems
- Measuring team performance
- Developing better testing procedures for technical training
- Reducing the cost of electronic maintenance training
- Providing a convenient shipboard training package for the detection of chemical warfare attack
- Developing display devices that provide a three-dimensional perspective to the viewer
- Classifying underwater contacts by new uses of acoustic information
- Evaluating new systems to determine compatibility with the capabilities of the human operator
- Taking the operator into account during the design and preparation of software
- Improving the quality of personnel record keeping
- Introducing electronic displays of technical information
- Preparing a requirements manual for an infrared system
- Using voice input and output in combat systems
- Developing better ASW simulation capabilities
- Improving displays for night carrier landing
- Diagnosing performance deficiencies and strengths in carrier landing practice.

MANPOWER AND PERSONNEL

In the Department of Defense, Manpower and Personnel RDT&E involves "Development of techniques/methods for utilizing available personnel resources through improved selection, job assignment, organization analysis and management techniques to meet combat-available and projected force needs."

The Navy must continually improve its manpower and personnel processes. These processes include: estimating life-cycle manpower requirements, developing more effective procedures for acquiring and classifying personnel, increasing productivity, and maintaining management capability to respond and adapt effectively to a changing force structure. A major focus at the present time is on finding ways to increase productivity and optimize the use of personnel resources while reducing or restraining costs.

Projects reported this year are:

- **Forecasting Long-Range Manpower Requirements**
- **Officer Personnel Management Models**
- **The Reallocation of Military Pay Increases**
- **Identification of Deliberate Failures in Selection Screening**
- **Marine Corps Enlisted Personnel Attrition**
- **Roadmap for Department of the Navy Family Research**
- **Manpower and Training Research Information System (MATRIS)**

FORECASTING LONG-RANGE MANPOWER REQUIREMENTS

Need

Navy planners are concerned about maintaining the proper size and mix of the naval work force in the face of rising civilian and military manpower costs and increasing complexity of fleet weapons systems. Intelligent assessments of the effects of fleet size and complexity on manpower requirements under various budgetary assumptions require manpower forecasting models which provide manpower requirement estimates for use in the Navy Planning, Programming, and Budgeting System (PPBS). Five-year forecasts are required to support the Program Objectives Memorandum (POM), while fifteen-year projections are necessary to support the Extended Planning Annex (EPA). As the Navy attempts to grow toward the goal of a 600-ship Navy, long-range manpower planning is more vital than ever.

The Office of the Chief of Naval Operations (Manpower, Personnel and Training) (OP-01) has responded to this need by sponsoring the development of a system of Long-Range Interactive Manpower Programming Modules aimed at providing planners with a direct, "hands-on" capability for use in managing the allocation of manpower resources.

Approach and Results

The Interactive Manpower Programming System (IMPS) houses several independent models and relatively small data bases which support these models in addition to an interactive information retrieval capability. IMPS focuses on forecasting military and civilian support manpower at the aggregate level (e.g., Program Element rather than Unit Identification Code). The system provides estimates necessary to sustain operating forces. One of the IMPS models is the Manpower Projection (MAPRO) Subsystem. MAPRO uses accounting procedures to forecast manpower assigned to forces. Forecasts of support and other manpower are based on statistical analysis of variables which impact support workload. The user can interactively select a forecasting scenario or specify his or her own scenario by responding to prompts from a time-sharing terminal. MAPRO's executive program calls subroutines that perform the manpower projections. In addition, MAPRO offers a wide range of graphic displays which greatly enhance the interpretability of model forecasts. The MAPRO subsystem is currently operating on both the Harris computer at the Navy Annex in Washington, DC, and the IBM 370 at the Department of Energy's Argonne National Laboratory in Chicago, IL.

Another model is the Naval Station and Naval Air Station Base Operating Support (BOS) Requirements Module. The primary objective of this module is to forecast aggregate military and civilian manpower requirements for major portions of BOS. The module is driven by a set of manpower estimating equations. An extensive data collection effort provided data on the physical size and population supported by a given BOS activity. These data were then matched with data describing the workload imposed by ship and aircraft forces resident at the activity. Multiple regression analysis was used to obtain these estimating equations. The Naval Station and Naval Air Station aggregate manpower forecasting models were integrated into the IMPS system in January 1982.

In addition to the IMPS models, another set of integrated analytical models for estimating aggregate military and civilian manpower was developed in FY 1982. A series of aggregate functional manpower equations produced manpower forecasts for the Navy support establishment. These models produce estimates for force-related support (ships, air, and other force support), central support (communications and intelligence), personnel support (recruiting, training and medical), and all other shore support.

Utilization

The Manpower Projection (MAPRO) Subsystem, and the Naval Station and Naval Air Station Base Operating Support (BOS) Requirements Module have been fully implemented and their uses were demonstrated in FY 1982. In addition, the system of aggregate functional manpower equations was applied in FY 1982.

The Naval Station BOS model was used by the Assistant for Base Operating Support, Deputy Chief of Naval Operations (Logistics) (OP-04) to "size" a new base in the Persian Gulf to support a new CV battle group. The BOS model was also used by the Director, Total Force Programming Division (OP-12) to estimate changes in naval station manpower requirements during the POM years FY 1984-FY 1988 in response to proposals to cut base operating support manpower.

The aggregate functional relationships were used in EPA development during July and August 1982. These models were incorporated into a "resource dynamics" model to show tradeoffs between new weapon system acquisitions and "cost of ownership" to the Navy. The results were presented to the Chief of Naval Operations and the Secretary of the Navy, among others.

Demonstrations of the MAPRO Subsystem of the IMPS interactive forecasting system were conducted in November 1982 for personnel in the Office of the Deputy Chief of Naval Operations (Manpower, Personnel and Training) (OP-01) and the Program Planning Office (OP-90). Specific MAPRO applications discussed were:

- Use of MAPRO capabilities to produce civilian manpower projections supporting participation in a 15 battle group working group.
- MAPRO application to manpower, personnel and training assessment group requirements. The figure below illustrates a MAPRO generated forecast of manpower through 1990 in response to user input of anticipated force increases.

The FY 1983 work plan includes finalizing a set of Defense Planning and Programming Category (DPPC) aggregate models, for utilization in the POM. IMPS will also be expanded in FY 1983 to accommodate more detailed models which address specific POM issues. Preliminary statistical relationships linking student workload to BOS manpower requirements at training activities have already been developed and incorporation into the IMPS framework is anticipated.

Impact

Because of the cost and scarcity of manpower resources, it is essential for Navy manpower managers to estimate future manpower requirements accurately and with a sufficient lead time. The series of computerized manpower forecasting models which make up this effort yields improved estimates for total Navy manpower requirements. These estimates are used to satisfy management budgetary requirements. The forecasting system provides a means for quickly obtaining estimates of manning requirements for a variety of ship and aircraft inventories.

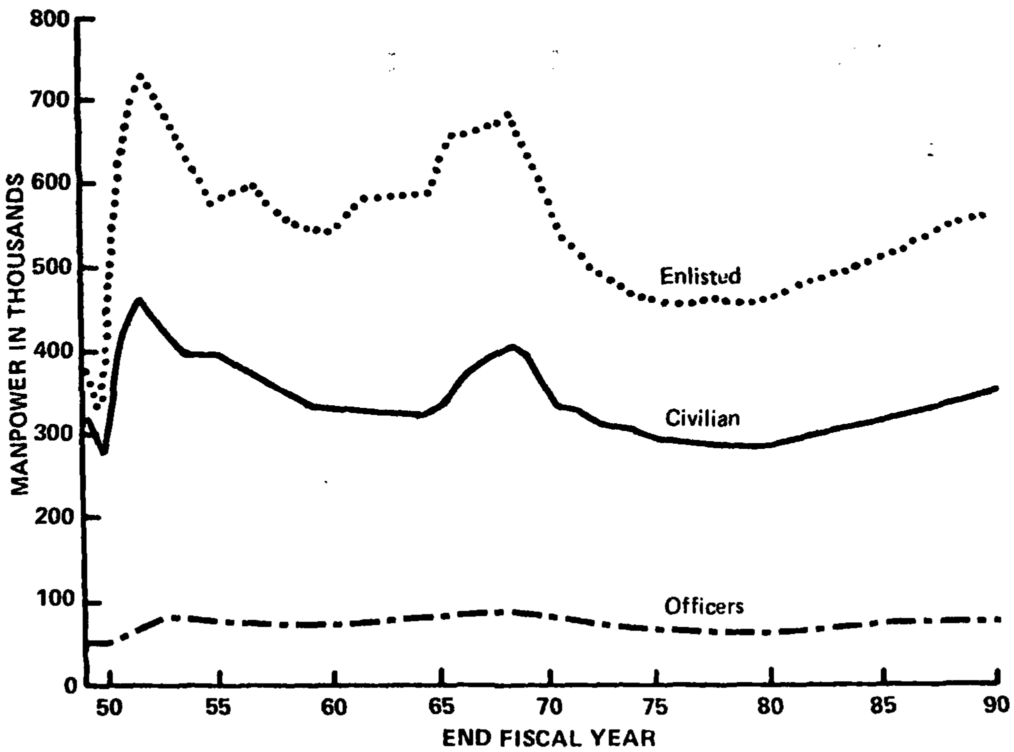


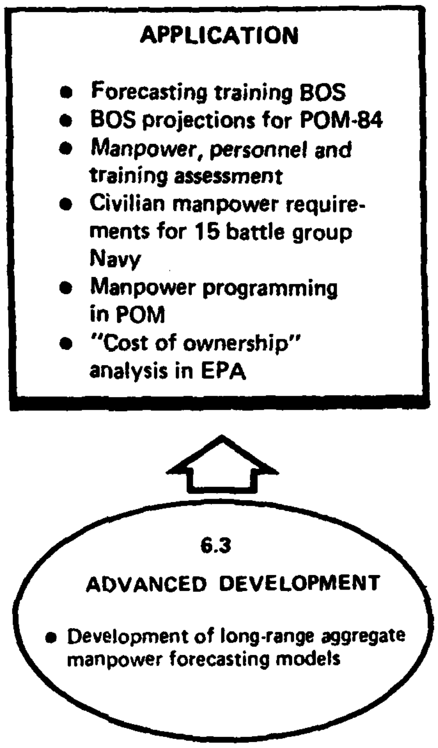
FIGURE: MAPRO Forecast of Manpower Through 1990.

Research and Development Notes

This work has been conducted by Mr. Thomas A. Blanco, Navy Personnel Research and Development Center (NAVPERSRANDCEN) (Code 11), San Diego, CA, 92152, (619) 225-7642. The Project is Z1186-PN, Impact of Fleet Configuration on Support Manpower, in Program Element 63707N, Manpower Control System Development. Research began in October 1976 and will continue through FY 1984. Several recent documents include:

- *A Model for Estimating Navy Manpower in Base Operating Support Programs;* NAVPERSRANDCEN Technical Report (TR) 82-28; Hudak, P., King, R., and Rhodes, C.; February 1982; Unclassified.
- *A Set of Integrated Analytical Models for Estimating Aggregate Military and Civilian Manpower for the Navy Support Establishment;* NAVPERSRANDCEN Working Paper; Blanco, T., Liang, T.; June 1982; Unclassified.
- *Estimating Manpower Requirements at U.S. Naval Stations for POM-84: Some Preliminary Results;* NAVPERSRANDCEN Working Paper; Blanco, T.; June 1982; Unclassified.
- *Estimating Aggregate Military and Civilian Manpower for the Navy Support Establishment by Defense Planning and Programming Category (DPPC)—Preliminary Results;* NAVPERSRANDCEN Working Paper; Brown, S., Shoecraft, M., and Thompson, T.; July 1982; Unclassified.
- *A Model for Estimating Base Operating Support Manpower Supporting Navy Training Programs;* MATHTECH, Inc.; November 1982; Unclassified.

Program dynamics are:



OFFICER PERSONNEL MANAGEMENT MODELS

Need

Recently, the Navy has undertaken a "rearming" program that will expand the fleet from roughly 490 ships in 1982 to 600 ships by 1989. The focal point of the larger fleet will be 15 battle groups (compared to a current 12). This rapid, yet sustained growth plan has forced manpower managers to assess carefully the ability of the officer and enlisted personnel systems to meet the manpower requirements of the larger fleet. Historically, the modeling support for this type of issue was either not available or involved time-consuming, manual coordination of tangentially-related models and estimates from different organizations. The need for a common tool for assessing the feasibility of future force sizes and configurations became apparent. In response to this need, the Deputy Chief of Naval Operations (Manpower, Personnel and Training) (OP-01) requested the development of a Structured Accession Planning System for Officers (STRAP-O).

Approach and Results

STRAP-O is a set of computer-based models capable of assessing quickly the feasibility of manpower goals, testing the sensitivity of the force to policy changes, and developing promotion and accession plans. Using predictions of personnel flow rates, starting inventories are successively projected by year into the future. These inventories, arranged by community or skill area, pay grade, and length of service, provide considerable detail for analyzing force behavior.

For the 600-ship Navy, the officer force was projected to 1990, utilizing expected military and civilian pay raises, inflation rates, likely accessions levels, and promotion opportunities. The projections show that the Navy should be able to equal or even surpass the total force requirement for officers by 1988 (see figure). STRAP-O also demonstrated that this growth could be achieved without harmful turbulence in accession or promotion policies. Finally, while total force needs are achievable, STRAP-O identified continuing shortfalls in some critical areas and pay grades.

Utilization

STRAP-O results formed the core of the report by the 15 Battle Group Working Group to OP-01 during late FY 1982.

Impact

A vital component of the Navy's ability to fulfill its mission is the presence of an officer personnel force adequate in both quantity and quality. Because the lead time needed to make major force changes is so great, strategic or farsighted force management is essential. STRAP-O provides manpower managers with support for making both near and longer term decisions.

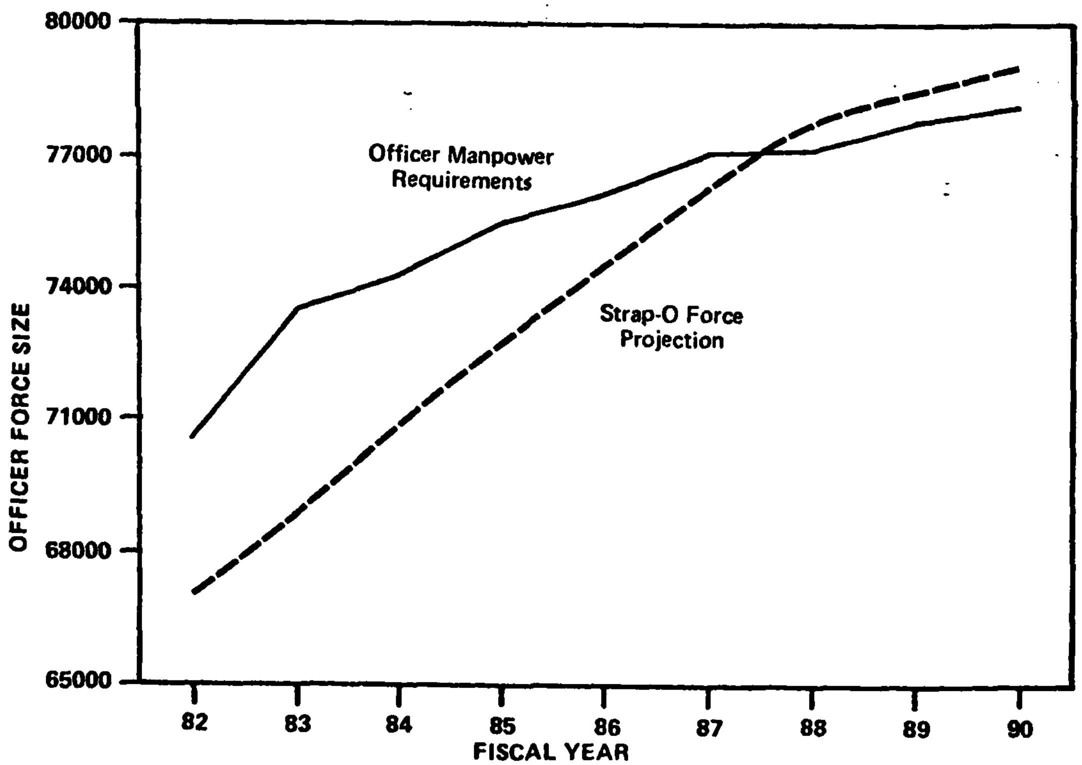
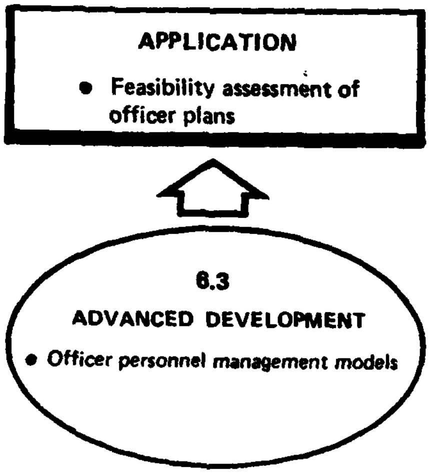


FIGURE: Officer Manpower Forecasts.

Research and Development Notes

This work was performed by Mr. Murray Rowe, Navy Personnel Research and Development Center (NAVPERSRANDCEN) (Code 11), San Diego, CA 92152, (619) 225-7388. It was funded in Program Element 63707N, Manpower Control System Development, as Subproject Z1187-PN.02, Officer Personnel Management Models, in Project Z1187-PN, Computer-Based Manpower Planning and Programming. The work was initiated in January 1981 and is continuing. Special Report (SR) 82-26, *Structured Accession Planning System for Officers (STRAP-O): A System for Assessing the Feasibility of Navy Officer Manpower Plans*, was published in June 1982. SR 83-17, *The Navy Officer Force Projection Model (OPRO)*, was published in March 1983.

Program dynamics are:



THE REALLOCATION OF MILITARY PAY INCREASES

Need

Under current law, there are several administrative mechanisms available for the manipulation of either the overall size or the distribution of military pay increases. These mechanisms were authorized to give the Executive Branch more flexibility in managing its economic and manpower programs. For example, the President is authorized to redistribute up to 25 percent of the annual increase in military basic pay into either the basic allowance for quarters (BAQ), the basic allowance for subsistence (BAS), or both. Additionally, the President is permitted to reallocate up to 25 percent of a pay raise to one or more selected pay grades. Further, Congress is allowed to fund different pay raises for different pay grades. This latter strategy is frequently called "pay targeting."

Approach and Results

To understand better the impact of reallocation and targeting on the pay of individuals and on military personnel budgets, the Navy Personnel Research and Development Center (NAVPERSRANDCEN) has constructed a computer-based model, called REALL, to estimate the pay rate and cost implications of pay increase and reallocation scenarios. Specifically, the model was used to examine the long-term effects of the FY 1977 and FY 1978 reallocations to BAQ combined with the FY 1982 pay grade targeting. This was then contrasted to estimates derived from simple across-the-board, nonreallocated pay increases generated by the REALL program. In addition, the estimated effect of reallocation on the take-home pay of typical personnel was examined by simulating various combinations of percentage pay increases and reallocation scenarios. A similar exercise was performed for costs, with particular emphasis on cost elements such as bonuses and retirement, which are linked to base pay and are informally identified as "drag along" costs.

The following are some of the major findings from this examination:

- Prior to the FY 1982 targeted pay increase, reallocation had caused basic pay in all pay grades to lag behind what it would have been without reallocation. Pay targeting in FY 1982 either increased or decreased the gap, depending upon the specific pay grade. The following figure illustrates the differences, depicting nonreallocated pay as a zero baseline. The reallocations in FY 1977 through FY 1981 caused both illustrative pay grades to lag; targeted pay increases in FY 1982 caused the E-6 to catch up, but increased the E-1 gap.

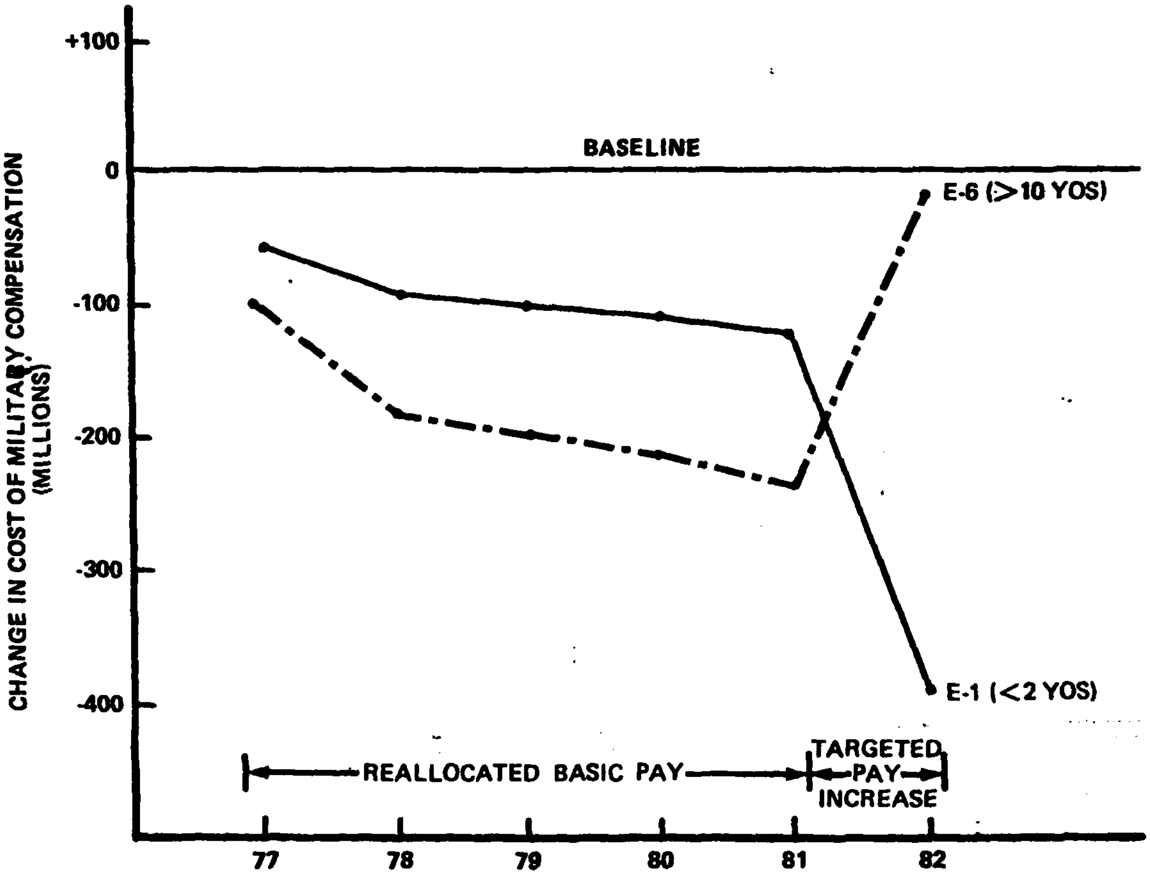


FIGURE: Difference in Reallocated and Nonreallocated Annual Basic Pay (Dollars).
Nonreallocated depicted as baseline to facilitate comparison.

- Because different proportions of each pay grade draw cash BAQ and/or BAS, any reallocating plan will cause pay raises to differ substantially among pay grades. When reallocating to BAS, lower enlisted pay grades suffer the most while lower officer pay grades receive the highest percentage increases.
- When pay grade reallocation is implemented, sizable pay raise differences occur, depending on the number of pay grades selected for a differential raise and the grade level. In such cases, the higher the pay grade or the fewer the number of pay grades selected, the greater the resulting differential pay increases.
- Compensation elements directly related to basic pay (e.g., bonuses, retirement) will also be increased when a pay raise is instituted. An example would be the amount an individual receives for a selective reenlistment bonus (SRB). If a pay increase is reallocated (from basic pay), the increase in basic-pay-related elements is reduced proportionally.
- The cost incurred by the government as a result of reallocation is dependent on the size of the pay increase, the type of reallocation, and the extent of reallocation. The cost to an individual service or the Department of Defense (DOD) is,

in addition, increased by "drag along" costs that increase proportionally with basic military compensation (BMC). Such outlays add about 20 percent of BMC to the overall cost.

- Because some personnel do not draw BAS or BAQ, increases in service costs are generally less than pay increase percentages, especially when increases are reallocated. For example, if 25 percent of a 10 percent pay raise were reallocated to BAS, the total cost to the Navy would be raised by only 8.99 percent rather than 10 percent.
- When the FY 1977 and FY 1978 reallocations are expressed in terms of total government costs over the 5-year period from FY 1977 to FY 1981, and contrasted to estimates of non-reallocated, across-the-board pay increases, a savings of roughly $998 million in BMC and related items results.

Utilization

In addition to the work described above, the REALL model has been used by the Deputy Chief of Naval Operations (Manpower, Personnel and Training) (OP-01) to evaluate pay raise plans posed by Congress, DOD, and the Navy. Continued use of the REALL model provides analysts with a clear estimate not only of direct costs related to pay increase and reallocation proposals, but all "drag along" costs as well.

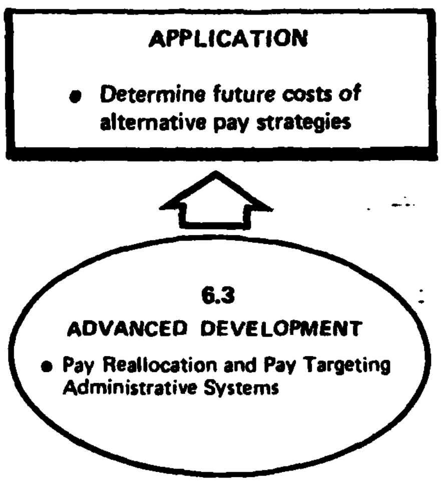
Impact

The use of the reallocation or targeting options can have a profound effect on the shape of the overall military compensation package, as well as the Navy, DOD, and federal government budgets. The BAQ/BAS reallocation process generates substantial short-term savings for the government, but only at the expense of reduced cash compensation for service members. The REALL program makes it possible for the analyst to evaluate alternative pay schemes in advance to determine the long- and short-term implications of such actions.

Research and Development Notes

This work was funded in Program Element 63707N, Manpower Control System Development. It was sponsored by the Deputy Chief of Naval Operations (Manpower, Personnel and Training) (OP-01). It was performed by NAVPERSRANDCEN, and is identified in Project Z1182-PN, Military Personnel Cost Projections, as Subproject Z1182-PN.03, Compensation and Incentives for Military Force Management. The responsible researcher was W. Wilcox, NAVPERSRANDCEN (Code 11). NAVPERSRANDCEN Technical Note (TN) 82-49, *Reallocation of Military Pay Increases,* W. Wilcox, June 1982, reports the work.

Program dynamics are:



IDENTIFICATION OF DELIBERATE FAILURES IN SELECTION SCREENING

Need

The Armed Forces Qualification Test (AFQT) score is used by the military services for mental screening of enlistment applicants and would likely be used for draft registrants if conscription were resumed. This score is computed from scores an applicant obtains on certain subtests of the Armed Services Vocational Aptitude Battery (ASVAB).

It is assumed that volunteers are motivated to perform well on the ASVAB subtests. If a military draft were reinstituted, however, some draft registrants would probably fail them deliberately to avoid military service. To reduce the number of registrants who use this method of draft evasion, a procedure is needed to identify examinees suspected of deliberately failing the tests.

The objective of the research reported here was to develop deliberate failure keys (DFKs) for the pertinent subtests in the six ASVAB forms in operational use (ASVAB 8, 9, and 10, Forms A and B), for use in the event a draft were resumed.

Approach and Results

The rationale used was the same as in earlier DFK development: true failures (service applicants unable to qualify for enlistment based on their AFQT score) mark different incorrect alternatives on multiple-choice enlistment items comprising the AFQT than do persons who deliberately try to fail the test. Test item responses were obtained for service applicants who were true failures, and for service recruits who were administered the ASVAB subtests used to compute the AFQT score with instructions to fail the tests deliberately "as if you were trying to avoid the draft."

The percentages of true failures (TFs) and deliberate failures (DFs) who answered each item alternative were computed. Two types of subkeys were constructed: (1) 25-item TF subkeys from items in which a larger proportion of TFs than DFs selected the alternative, and (2) 25-item DF subkeys from items in which a larger proportion of DFs than TFs selected the alternative. The subkeys were combined to form a 50-item DFK for each ASVAB form. Typical distributions of true and deliberate failures on the 50-item key for one test form are presented in the figure below, to demonstrate the separation of the two groups.

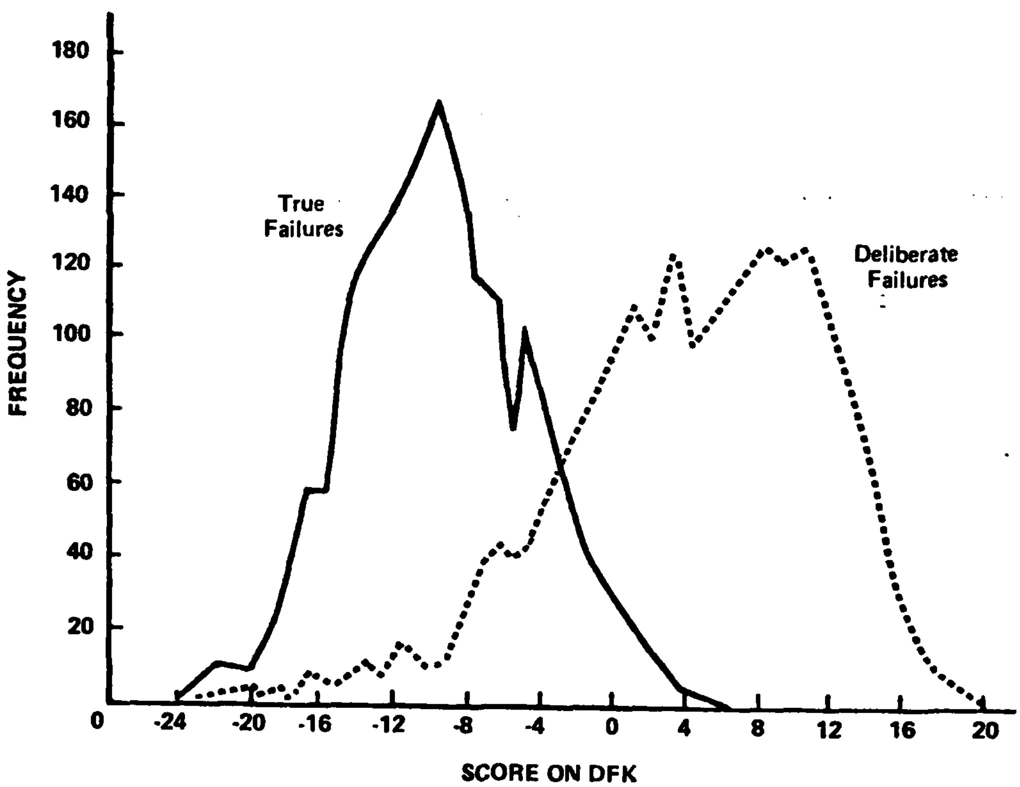


FIGURE: Typical Distribution of True and Deliberate Failures on the Operational DFK. *Data based on ASVAB Form 8B.*

Cutting scores on the DFKs were established to classify examinees into one of three categories: TF, DF, and undetermined.

The validities of the 50-item DFKs recommended for operational use ranged from .65 to .75 for the ASVAB forms. The cutting score for the DF category resulted in less than 1 percent of the TFs being misclassified as DFs. The undetermined category, the group that must be evaluated by interview and other means to determine suitability for service, included 19 to 25 percent of TFs and 31 to 45 percent of DFs, depending on the test form.

Utilization

The Department of Defense has accepted the six Deliberate Failure Keys developed in this study for use if a draft is resumed. Keys have been forwarded to the Military Enlistment Processing Command for distribution to testing sites under their command.

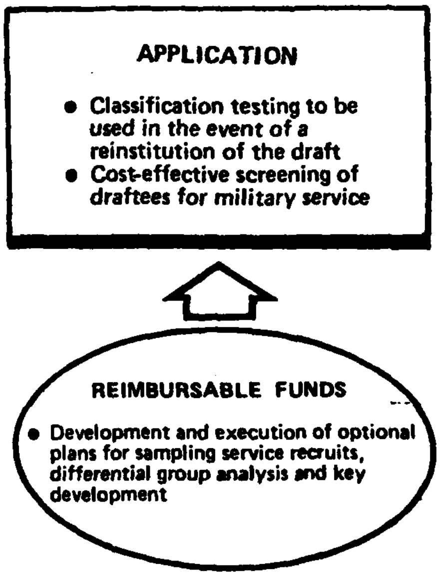
Impact

The DFKs developed for the subtests in ASVAB Forms 8, 9, and 10 that are used to compute the AFQT score are sufficiently valid to classify examinees into DF, TF, or undetermined categories. Use of the DFKs in a draft environment would materially reduce the processing workload at *military enlistment processing stations.*

Research and Development Notes

This project was performed by the Navy Personnel Research and Development Center (NAVPERSRANDCEN), San Diego, CA. It was sponsored by the Assistant Secretary of Defense (Manpower, Reserve Affairs, and Logistics) and was conducted through Operations and Maintenance, Navy funding. The responsible researchers were Messrs. Leonard Swanson and Paul Foley, NAVPERSRANDCEN (Code 12), (619) 225-2181. A recent Special Report is NAVPERSRANDCEN SR 83-4, *Development of Armed Forces Qualification Test (AFQT) Deliberate Failure Keys for Armed Services Vocational Aptitude Battery (ASVAB) Forms 8, 9, and 10*, November 1982 (Distribution limited to U.S. Government Agencies only).

Program dynamics are:



MARINE CORPS ENLISTED PERSONNEL ATTRITION

Need

The attrition rate among first-term enlistees increased through the 1970s and was running from 30 to 40 percent after movement to the all-volunteer force. This rate of attrition was magnified by the costs of attrition and by a decline in the 17-21 year old male primary recruiting pool projected for the remainder of the twentieth century. These facts could lead to problems in maintaining military manning levels and readiness. Although attrition and retention are directly influenced by the national economy, it can be anticipated that both will resurface as major challenges for military managers as the economy improves.

These considerations have caused greater attention to be focused on achieving a better understanding of the causes and correlates of attrition among first-term enlistees prior to the end of the enlistment, and the exploration of counter-attrition strategies for reducing attrition and increasing retention.

The three major components of this study were:

- To track longitudinally a cohort of 1,500 male, first-term enlistees who entered the Marine Corps in 1976.
- To extend the 1976 study to samples of male and female first-term enlistees who entered the Marine Corps in 1977 and 1978. This phase provided an opportunity to evaluate the generalizability of results from the 1976 sample.
- To evaluate experimentally the effects of a realistic job preview on attrition rates for a sample of 1978 accessions. This component of the study was labeled Parris Island Recruit Assimilation Training Exercise (PIRATE).

Approach and Results

The study evaluated changes in Marine Corps recruit perceptions, expectations, values, and behavioral attitudes, intentions over four years, and related such changes to attrition and reenlistment. The original longitudinal sample consisted of 1,445 male, first-term, non-reservist enlisted personnel who entered the Parris Island Recruit Training Depot in August 1976. Recruits were surveyed before and after recruit training and while on their first duty station. Personnel who attrited from recruit training or from their first duty station completed an exit survey.

Characteristics measured included individual variables (age, education, race, initial expectations, and behavioral intentions to complete the first enlistment) as well as organizational variables (perceptions of leadership, the work group, and job content). Criteria included attrition and reenlistment behavior, training performance, and on-the-job performance.

Two major questions guided the original study:

- Can "early leavers" (those who attrite during recruit training) be distinguished from "later leavers" (those who attrite after recruit training) and "stayers" (those who complete their enlistment or choose to reenlist)?
- Can "later leavers" be distinguished from "stayers" in terms of observed changes in key components of the attrition model developed in the study?

Results from the original study supported a number of conclusions. "Early leavers" were clearly different from "stayers" on measures taken at the beginning of recruit training. Cognitive and attitudinal variables measured at the time of entry into the Marine Corps both contributed significantly to the prediction of membership in "leaver," "stayer" or reenlistment groups. This finding has implications for the identification of high-risk turnover groups and for the design of counseling or coaching programs for high-risk personnel. It was also found that "later leavers" generally exhibited different patterns of attitude change over time than the "stayers," on key components of the attrition model. This finding highlights the importance of accurate expectations and/or the modification of job content and leadership variables.

Two studies conducted in 1977 and 1978 tested the generalizability of the recruit training results for the original 1976 Parris Island sample. Findings generally supported those of the original study.

Since experiences encountered by an individual prior to and shortly after entry into a new organization have a profound effect upon the individual's attitudes and behavior, it was hypothesized that a realistic job preview (RJP) could reduce recruit attrition. This intervention (PIRATE) was field tested in 1978 on a sample of 978 enlisted male recruits. PIRATE consisted of an 80-minute color video tape which portrayed a realistic picture of the recruit training experience. The content of this preview was based upon observations of recruit training, previous research results, and on extensive interviews with over 300 recruits, drill instructors, and other Marine Corps personnel. The preview was administered to personnel on the second day of recruit training.

Results demonstrated that six and twelve months after accession, recruits exposed to the RJP had significantly lower attrition rates than control groups. Performance, as measured by Military Skills Marks, was also significantly higher for recruits exposed to the RJP. This experiment illustrated the potential utility of realistic previews as an effective counter-attrition and socialization strategy, and suggested potential applicability beyond recruit training.

Utilization and Impact

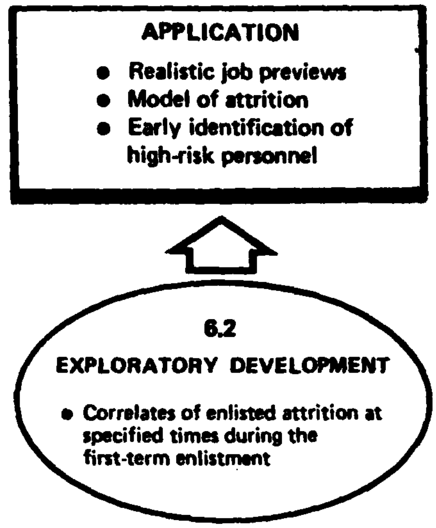
These results will enable Navy and Marine Corps managers to reduce enlisted attrition by using realistic job previews before recruit training. The identification of high-risk recruits is also feasible, and may provide a basis for differential treatment during recruitment, induction, and early training. Of more general applicability is the attrition model

developed during the course of this study. This model has been used and validated in a number of subsequent studies, including a longitudinal examination of Navy enlisted attrition conducted by the Navy Personnel Research and Development Center.

Research and Development Notes

The Chief of Naval Research sponsored this project in Program Element 62763N, Personnel and Training Technology. The project was initiated in 1976 and completed in 1982. The responsible researcher was Dr. B. T. King, ONR (Code 442OE), Arlington, VA, (202) 696-4741. The principal investigator was Dr. W. H. Mobley, Texas A&M University, College Station, TX, (713) 845-4711. Fourteen technical reports, nine journal articles, and one book were generated from this project.

Program dynamics are:



ROADMAP FOR DEPARTMENT OF THE NAVY FAMILY RESEARCH

Need

During the mid-to-late 1970s, the Navy and Marine Corps came to give vigorous attention to the importance of families to military life. The Navy Family Program was initiated and a Family Programs Branch was established in January 1979, in the Office of the Deputy Chief of Naval Operations (Manpower, Personnel and Training) (OP-01). The mission of this Branch is to improve Navy awareness of, and utilization of, reliable and useful information, resources and services that support and enrich the lives of Navy personnel and their families.

Five major objectives have been set forth. They are:

- To establish a network of Family Service Centers.
- To provide training, technical assistance, positive support, and guidance, to commands desiring to develop or improve their own family support programs.
- To develop awareness programs emphasizing the importance of families to the Navy's mission.
- To increase effective coordination and use of existing Navy civilian resources.
- To conduct or sponsor research which documents and guides Navy family efforts and policies.

To accomplish the last objective, data and information must be developed, with which to guide future policy and direction for the Navy Family Program effort. A plan or "roadmap" was needed to guide and coordinate the required research and development.

Approach and Results

A three-pronged approach was utilized to develop the plan. First, semi-structured interviews were conducted with approximately 100 individuals representing offices dealing with family policy, persons involved in the conduct of family programs, researchers, family constituency groups, and family policy staffs in federal and other agencies. Second, an extensive review of the literature was conducted to identify existing knowledge. Finally, a comprehensive charting technique was used to organize

potential research topics into logical sequences of research objectives contributing to Navy Family Program objectives.

A total of 108 research areas was identified and organized within sequential arrays relating to: generic, multi-problem family issues; deployment issues; medical and dental care; financial counseling; child care; housing; and child and spouse abuse. For each research area, key research issues were described and existing knowledge briefly summarized. Finally, research management principles were identified for maximizing the utility of Navy family research.

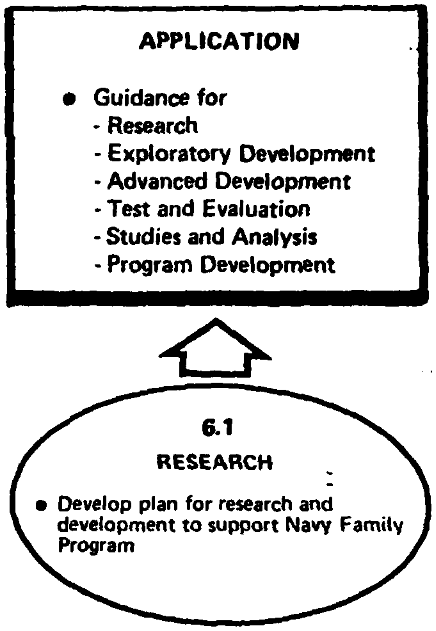
Utilization

Since its completion, the "roadmap" has served several valuable functions. First and foremost, it provides a clear, semi-prioritized plan that the Navy research community uses to allocate resources, plan present and future programs, divide responsibilities among cognizant activities, and evaluate work proposed by potential contractors. It also is used routinely to inform interested researchers of specific Navy needs for research, development, and evaluation. In addition, the roadmap has served as a generic model for research planning; at least one other major Navy program area (Civilian Personnel) is working on the development of a "roadmap" to support and improve its operations through coordinated research and studies.

Research and Development Notes

This work was funded by the Office of Naval Research through its Organizational Effectiveness Research Programs. The scientific officer was Dr. Robert Hayles (Code 442). It was performed by the Westinghouse Public Applied Systems Division in Columbia, MD with Mr. Gerald Croan as principal investigator. The effort was coordinated with and advised by representatives from the Navy Family Program; Naval Health Research Center; Navy Personnel Research and Development Center; Headquarters, U.S. Marine Corps; Bureau of Medicine and Surgery; Navy Military Personnel Command; and the Military Family Resource Center. The roadmap reference is *Roadmap for Navy Family Research*, Westinghouse Public Applied Systems Division, Columbia, MD, authored by G. Croan, R. Katz, N. Fischer, A. Smith-Osborne, and L. Dutton, August 1980 (AD A088575).

Program dynamics are:



MANPOWER AND TRAINING RESEARCH INFORMATION SYSTEM (MATRIS)

Need

Today's research and development managers, directors, and practitioners face formidable obstacles in making decisions about what research should be undertaken. The ability to make decisions hinges on available information and the system through which the information is provided. Accordingly, a variety of information systems have been developed to support segments of the Department of Defense (DOD) RDT&E community. Each of these systems serves only the purpose of that community for which it was developed. What is needed is a single, integrated, on-line automated information system that would be accessible to all managers and researchers with people-related RDT&E responsibilities.

Approach and Results

The Manpower and Training Research Information System (MATRIS) is the result of the merger in FY 1981-1982 of the Training and Personnel Systems Technology (TPST) System and the Research and Development Information System (RDIS), applying major modifications to the resulting effort. The TPST system contained ongoing program elements, products, and tasks, as well as historical data on work begun since FY 1980. The RDIS data base was work unit oriented, using Research and Technology Work Unit Summaries (1498s), the Navy's Laboratory Program Summaries (LPSs), and other documents, such as the Air Force's Management and Science Information System (MASIS) reports. In September 1982, management control of MATRIS was transferred from the Navy Personnel Research and Development Center (NAVPERSRANDCEN) to the Defense Technical Information Center (DTIC). MATRIS operates on DTIC's computer facilities.

Utilization

MATRIS is being used by managers and researchers in the DOD manpower, personnel, and training RDT&E community to track research efforts and to provide data for congressional reporting and program management. The present system is available to selected research laboratories and Office of the Secretary of Defense personnel. As the system is improved and expanded, it will be accessible by all DTIC registered users.

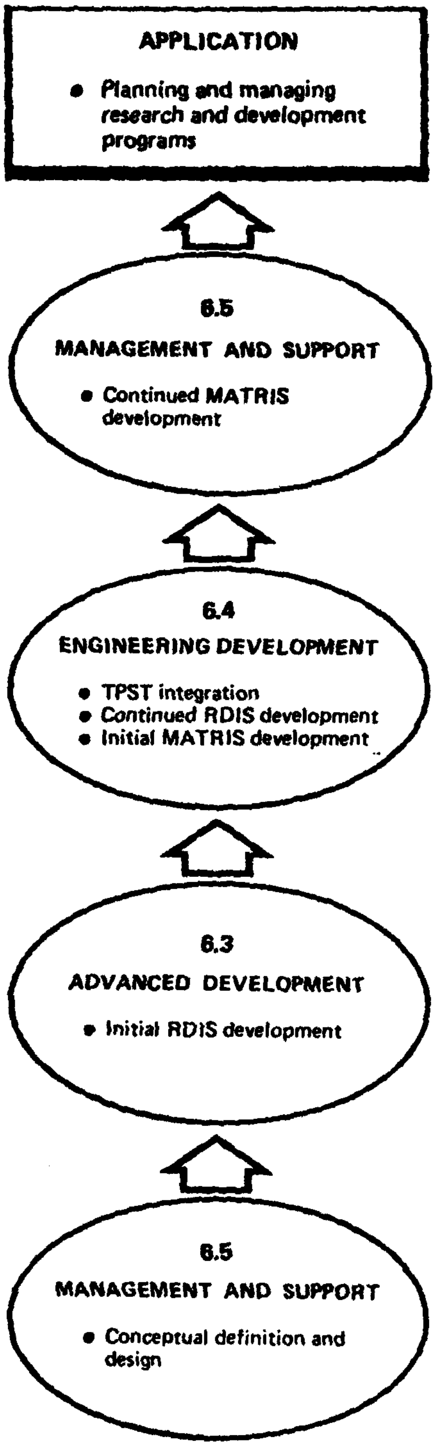
Impact

MATRIS is intended for the widest possible use in planning and managing people-related RDT&E programs. Its comprehensive data base can be used to relate research efforts to DOD objectives and issues to obtain future support from Congress and maximum return on the RDT&E investment of the individual services. Because MATRIS is also intended to serve as a prototype for similar systems for other RDT&E areas, it can be expected to have far-reaching implications for improvements in the overall management of RDT&E in DOD.

Research and Development Notes

The Navy Personnel Research and Development Center had the lead responsibility for the development of MATRIS *under the general sponsorship of* OASD (MRA&L), OUSDR&E, and the Deputy Chief of Naval Operations (Manpower, Personnel, and Training) (OP-01). Funding was provided from several sources including Program Elements 63720N, Prototype Manpower/Personnel System; 65804N, Technical Information Services; and 65861N, DNL Management Support Systems. The responsible researcher was Ms. L.L. Richards, NAVPERSRANDCEN (Code 303), who now heads the DTIC MATRIS office in San Diego, CA, (619) 225-2056.

Program dynamics are:



EDUCATION AND TRAINING

This area of People-Related RDT&E is defined in the Department of Defense as the "Development of education and training methods and media for managing, designing, and evaluating new-generation instructional systems for military application."

The Navy training establishment faces major challenges in trying to maintain personnel readiness to meet operational demands while it is faced with economic restrictions, manpower competition, and the increasing sophistication of weapons. New technology is being developed to focus training objectives on actual job requirements, to reduce training costs and improve efficiency, to improve the availability of training, and to adapt training to the needs of the individual.

The projects summarized in this Annual Report are:

- **Improving Fundamental Reading Skills**
- **Shipboard Propulsion Plant Operator Training (SPPOT) Program**
- **Improving Team Performance Measurement**
- **Handbook for Testing in Navy Technical Training**
- **Simulation in Maintenance Training**
- **Training Package for the Chemical Warfare Directional Detector**

IMPROVING FUNDAMENTAL READING SKILLS

Need

The volume and complexity of the material that military personnel are required to read has increased markedly over the last few years, but the reading skills that the average recruit brings to the services have not improved. The gap between what recruits can read and what they should be able to read to do their job will widen dramatically as more complex equipment is brought into the fleet. Moreover, the time it takes to train a recruit to even minimum standards for performing complex operations and maintenance jobs may well continue to increase, partly as a consequence of the increased burden of reading and comprehending more complex training materials.

There is, therefore, an urgent need to develop a technology for enhancing reading skills, one that does not fall prey to the chicken-and-egg problem that results when one tries to train people to read better by trying to force them to read more. The intent of this research program has been to start with a painstakingly validated theory of the mental processes that occur during reading. This theory was then used to generate specifications for the design of computer-based instructional games. These games provide massive practice on the mental processes which are bottlenecks for deficient readers.

Approach and Results

The details of a theory of the reading process were generated and validated in a series of experiments in which the reading task was broken down into its elementary components. Examples of such components are the visual recognition of letters and multiletter units, and the generation of a phonetic, or speech-like, code for each unit. Then several possible experimental measures of the efficiency of each component were designed, and precise predictions about the interrelatedness of performance on each of these measures were derived and tested. The resulting set constitutes a Reading Components Battery, which is a set of experimental measures which can be used not only to predict reading ability, but also, and more importantly, to diagnose deficiencies in one or more of the component processes which appear to underlie the ability to read. Using the measures from this battery, the specific mental processes which have the greatest expected effect on reading skill were identified.

Once the processes were known and the technology existed for measuring their efficiency in a particular reader, the task of designing ways to provide massive, specifically targeted practice could begin. Since thousands of trials of, for instance, encoding multiletter units is an unappetizing prospect for a student, the practice had to be embedded in a motivating context. Therefore, a set of computer-based games addressing each of the key bottleneck processes was designed. Research at this stage was directed toward ensuring that the games would force the student to exercise precisely the mental processes which need practice. The tasks had to be carefully revised and tested to eliminate the possibility that alternative strategies could be used which did not require the use of the target mental processes.

When the preliminary design and implementation of each game was complete, it was tested for its instructional impact on individual deficient adult readers. The goal here was not a large-scale evaluation, but rather a precise experimental verification that the speed and efficiency of the target processes had in fact been increased by the training, and that these increases had had their predicted effect on reading speed and/or comprehension. At this point, the implementation of versions of the games suitable for large-scale evaluation and use in instruction can begin. Current plans call for the development and implementation of a set of instructional systems for five key areas of reading. In addition, the Reading Components Battery will be converted into a tool for wider use in diagnosing reading deficiencies. A Spanish-language version of this battery is also under development, and plans call for testing the impact of the instructional games for bilingual as well as monolingual students.

Utilization and Impact

This technology can be included as part of Academic Remedial Training, Job Oriented Basic Skills Training, or other programs which prepare students for schoolhouse instruction. The intensive training in essential components of reading that these games provide will not only enable deficient readers to read faster and interpret complex text more accurately. This should lead to a greater proportion of students successfully completing

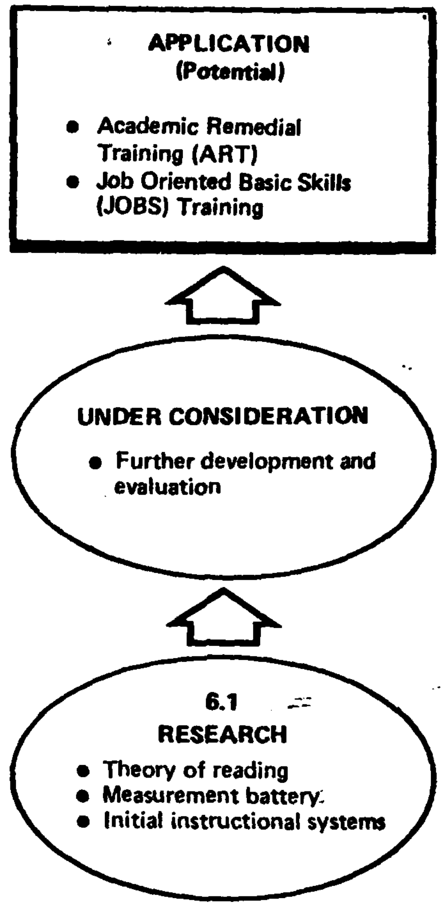
training. In the fleet, the effect will be felt as a reduction in errors in complex maintenance and operational tasks which depend on precise interpretation of technical manuals.

Research and Development Notes

This work was supported by the Office of Naval Research (ONR) during the development of the theory of reading, the measurement battery, and the initial three instructional systems. It was funded in Program Element 61153N (Defense Research Sciences), Subelement 42 (Behavioral and Social Sciences) during the years 1976-1982. The work was monitored by Dr. Marshall Farr and Dr. Henry Halff, ONR Code 442PT, Arlington, VA, (202) 696-4741. Further development and evaluation is being considered for joint support by the Office of Naval Research, the Navy Personnel Research and Development Center, and the Army Research Institute.

The initial theoretical breakthroughs that lie behind the development of the instructional systems were the result of research by Dr. John Frederiksen of Bolt, Beranek, and Newman (BBN), Inc. Dr. Frederiksen collaborated with Dr. Phyllis Weaver, Ms. Helen Gilotte, and Ms. Beth Warren, all of Harvard University, in designing the initial training systems. Seven technical reports have been published, including Frederiksen, J.R., *A componential theory of reading skills and their interactions*, (BBN Rept. No. 4649), Cambridge, MA: Bolt, Beranek and Newman, April, 1981; and Weaver, P.A., Frederiksen, J.R., Warren, B.M., Gilotte, H.P., Freeman, B., and Goodman, L., *Perceptual units training for improving word analysis skills*, (Tech. Rept. No. 1), Cambridge, MA: Harvard University Graduate School of Education, March, 1982.

Program dynamics are:



SHIPBOARD PROPULSION PLANT OPERATOR TRAINING (SPPOT) PROGRAM

Need

Many fleet personnel must learn a major portion of their jobs through shipboard training. For example, up to 50 percent of the engineering personnel reporting aboard surface ships have not received any technical school training, yet they must learn to operate and maintain complex systems such as the 1200 psi propulsion plant, which contains thousands of components. Even those personnel who do attend shore-based school seldom have the opportunity to practice with the kinds of equipment and procedures they must work with on the job. Thus, when they arrive at their first duty station they must supplement their shore schooling with on-the-job training using specific shipboard equipment and procedures.

The shipboard environment is not conducive to training activities. The main propulsion spaces, in particular, are crowded, hot, and noisy. A method is needed for designing shipboard training that is compatible with constraints of the operational shipboard environment, and that can meet the ship's needs for competent personnel to operate and maintain the complex systems. Much of the research in training technology and development has been directed toward the Navy's formal schools, and many of the instructional techniques developed for this environment may not be suited for use aboard ship. To be successful, shipboard training must be tailored to meet the needs and the constraints of operating Navy ships.

Approach and Results

The development of improved methods of shipboard training required the following steps:

- Definition of performance problems based on ships' needs
- Determination of requirements, constraints, and alternative methods, based on fleet priorities and environmental considerations
- Selection of a solution strategy
- Implementation of the solution
- Evaluation of the effectiveness and generalizability of the solution.

In order to define ship performance problems and needs for improved onboard training methods, a survey was conducted of several hundred personnel aboard aircraft carriers. Main propulsion performance was identified as the most critical problem in the fleet, and further analysis disclosed that the specific operational requirement was to establish a qualified three-section steaming watch. That is, a training program was needed that would qualify propulsion personnel to perform all major plant operational tasks. The program had to be performance oriented and designed for use "on the deckplates," with instructional materials that were sufficiently self-explanatory so that personnel could learn on the job with minimum classroom instruction.

To meet the requirement, a complete Shipboard Propulsion Plant Operator Training (SPPOT) program has been developed. It consists of procedural training aids, equipment and piping location aids, and instructional modules. The procedural aids (SPPOT Guides) assist the operator in learning how to operate the propulsion plant, by presenting step-by-step procedures, including action alternatives. The figure below illustrates:

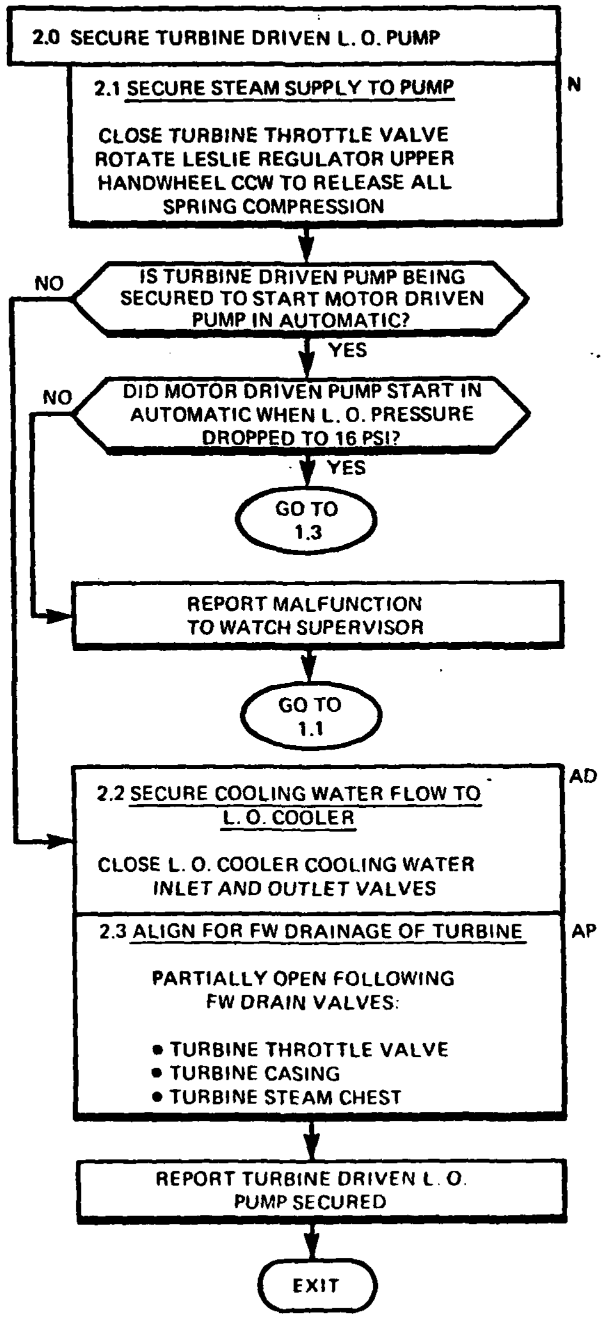


FIGURE: Sample Portion of SPPOT Guide.

SPPOT instructional modules provide basic training information common to all watchstations, and detailed information required for operation of the equipment and systems for each of the individual watchstations. The locational aids enable the operator to identify the equipments and trace the piping systems with which he is working. SPPOT also contains the materials necessary to integrate this training program with the Performance Qualifications Standards (PQS) system.

Utilization

The SPPOT products were initially developed and implemented aboard USS CONSTELLATION (CV 64). The results of this pilot ship application were so promising that additional applications have been made to USS SARATOGA (CV 60) and to three frigates: USS LANG (FF 1060), USS DOWNES (FF 1070), and USS HEPBURN (FF 1055). An important generalization from 1200 psi to 600 psi was accomplished in implementing SPPOT aboard the battleship USS NEW JERSEY (BB 63). The Conventional Marine Propulsion Training Steering Committee is currently exploring the possibility of generalizing SPPOT to all 600 psi - 1200 psi propulsion plant ships.

A SPPOT Development Handbook was produced that provides step-by-step procedural guidance for the production of SPPOT materials. This Handbook facilitates the transition of the SPPOT program from what was largely a research and development effort into what can be primarily a production effort, accomplished by military training personnel and subject matter experts.

This program has demonstrated that it is possible to develop a practical training system which satisfies the actual shipboard performance requirements and which functions within the constraints of the real-world environment of operational ships. The response from shipboard users to the SPPOT program has been uniformly positive, and its utility and generalizability have been demonstrated by its successful implementation in a variety of Navy ships.

Impact

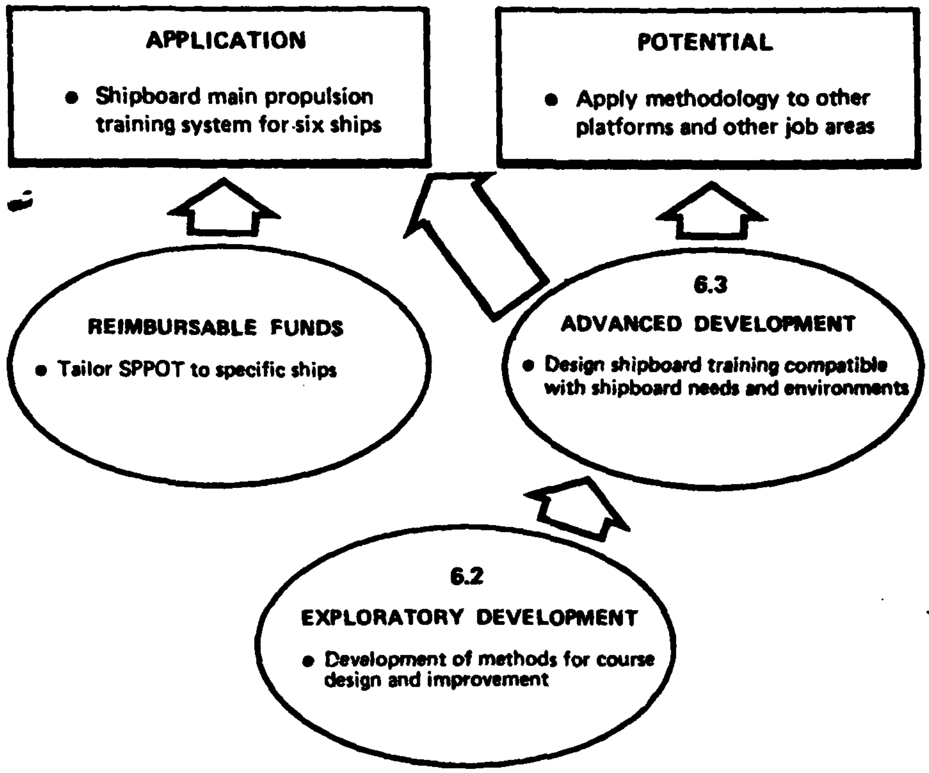
The SPPOT program can improve fleet readiness in the following ways:

- SPPOT provides a means for design of onboard training, compatible with operational shipboard environments.
- Procedural training aids provide a means to conduct hands-on operational training despite a fleet-wide reduction in opportunities for practice under steaming conditions.
- Ships will be better able to qualify and maintain a three-section main propulsion watch, which will enhance the capability of ships to steam on a 24-hour basis.
- The training program will compensate for the attrition of senior personnel who serve as experienced operators and as instructors for new personnel.
- SPPOT makes it easier for propulsion engineering personnel to acquire the specific knowledge and skills required to qualify under the PQS system.
- The production of SPPOT training materials could be accomplished by military training personnel following the procedures provided by SPPOT Development Handbook.

Research and Development Notes

This work was performed by NAVPERSRANDCEN, San Diego, CA, starting in 1976 and continuing through 1983. It was sponsored initially by the Director, Naval Education and Training (DNET) (OP-099) and later by the Deputy Chief of Naval Operations (Manpower, Personnel and Training) (OP-01). The early work was performed in Program Element 62763N, Personnel and Training Technology, as a Work Unit entitled Alternatives to Formal School Instruction. Follow-on work was accomplished in Program Element 63720N, Education and Training, as Subproject Z0108-PN.33, Application of Instructional Technology to Shipboard Training (1976-1978), and later as Subproject Z1180-PN.01, Enhancing Fleet Readiness Through Improved Shipboard Training, in Project Z1180-PN, Techniques for Shipboard Training. There have been three principal investigators: Dr. Macy Abrams; LCDR Iver J. Rivenes; and currently Dr. Kirk Johnson, (619) 225-7122. Five Technical Reports (TRs) have been published. They are: *Tailoring Shipboard Training to Fleet Performance Needs: I. Approach and Initial Efforts*, TR 78-30, August 1978; *II. Propulsion Engineering Problem Analysis*, TR 81-23, September 1981; *III. Development of Deck-Plate Procedural Training for the Shipboard Propulsion Plant Operator Training (SPPOT) Program*, TR 82-6, October 1981; *IV. Training Modules and Administrative Aids for the Shipboard Propulsion Plant Operator Training (SPPOT) Program*, TR 82-61, August 1982; and *V. Design and Production of Training Materials*, TR 83-9, February 1983.

Program dynamics are:



IMPROVING TEAM PERFORMANCE MEASUREMENT

Need

Measures of team performance are usually subjective or nonexistent. One reason is that performance standards are usually lacking; detailed standards are necessary to provide accurate feedback and reliable performance measurement. A second reason is that efficient procedures are needed for developing and implementing objective team assessment; procedures are needed that reduce the effort of task analysis by taking advantage of the large amount of existing information on Navy team operations.

Approach and Results

Procedures were established for developing team training objectives, developing performance checklists based on the objectives, and using the objectives in team training. The procedures were applied to selected anti-submarine warfare (ASW) training tasks at the Fleet Anti-Submarine Warfare Training Center, Pacific (FLEASWTRACENPAC). The initial application was to Search-Attack Unit (SAU) exercises conducted in the 14A2 single-ship team trainer. The exercises provide training for ASW team members in the Combat Information

Center, Underwater Battery Plot, sonar and bridge. SAU exercises in the 14A2 trainer provide a simulation of the crew's own ship, a main body that they are assigned to protect, an assist ship with which their ship operates, one or two helicopters used to support the operations, and one or two enemy submarines whose primary goal is to attack the main body.

The SAU exercises were selected for initial development of training objectives and performance measures because of the great variety of team activities and skills involved—the intent was that the analysis provide a model for application to other types of team training. Subsequent applications were made to target motion analysis, in which the ASW team plots the position and course of a submarine using own ship's passive sonar, and to passive localization using sonobuoys.

The objectives and checklists were tried out in three courses at FLEASWTRACENPAC and revised. Preliminary results indicate that the checklist scoring is highly reliable and fosters improved team performance in training.

Procedures for revising team training courses were developed and applied to an ASW course. The procedures include preparation of a Pretraining Guide to assist teams in preparing for ASW team exercises. The revised course and the Guide were based on the objectives and checklists previously developed. The new course and the Guide have been well received by instructors and ships' teams.

Utilization

The objectives and checklists are in use in four courses at FLEASWTRACENPAC: ASW Team Training (Active Sonar) for non-NTDS ships; Target Motion Analysis, Basic; Sonobuoy Plotting and Air ASW; and ASW Team Evaluation, Phase I. The Pretraining Guides are being used aboard ship. The objectives and checklists are currently being modified for shipboard training for three classes of NTDS ships. Guides are being prepared to aid applications to other kinds of team training.

The objectives and checklists are being used by the Chief of Naval Education and Training and FLEASWTRACENPAC to aid in the design of new trainers to replace the 14A2 single-ship team trainer and the 14A6 multi-ship team trainer. The materials are also in use as criterion measures in team research sponsored by the Office of Naval Research.

Impact

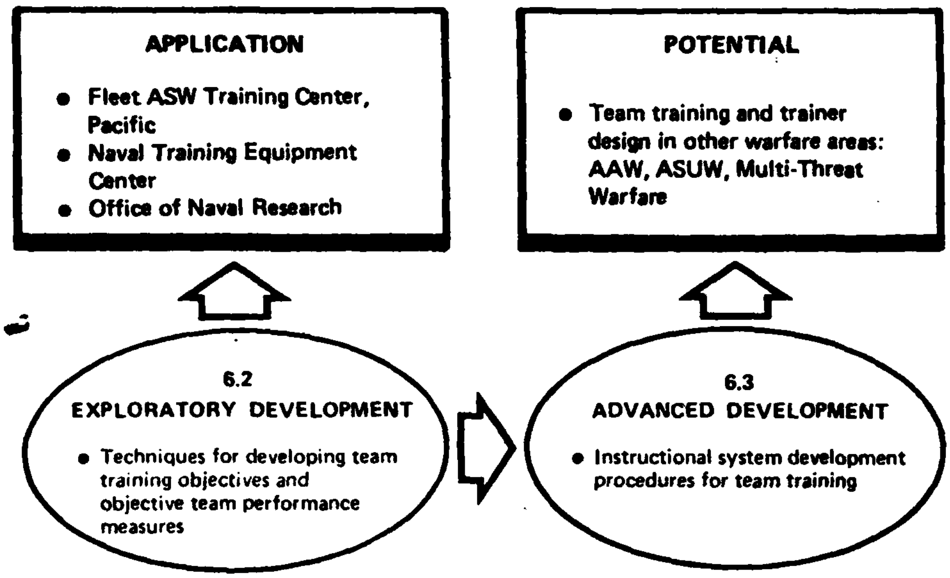
It appears that objectives and checklists that provide specific team member actions and performance standards will find wide usage. In addition to the applications mentioned above, there are plans to incorporate the materials in the Combat Systems Training Architecture for Commander, Surface Forces, Pacific Fleet. It is likely that some version of the materials will be used at other ASW training centers and by the Fleet Combat Training Center, Pacific.

The procedures developed on this project should be directly applicable to other areas of team training. An Advanced Development project, Improved Procedures for Developing Team Training, is planned to start in FY 1985. This project will build on the work done in the current project. One of the things the new project might do is develop techniques for performance assessment in more complex cases such as multi-threat warfare.

Research and Development Notes

The Navy Personnel Research and Development Center (NAVPERSRANDCEN) conducted this research beginning in FY 1978 and ending in FY 1983. It was sponsored by the Office of Naval Research, Code 270, under the title, Team Training for Tactical Environments, Work Unit RF63-522-001-010-0?.02 in Program Element 62763N, Personnel and Training Technology. The principal investigator was Dr. Dewey A. Slough, NAVPERSRANDCEN (Code 13), (619) 225-7121. Relevant documents include: NAVPERSRANDCEN Technical Note (TN) 81-18, *Development of antisubmarine warfare team training objectives*, June 1981; NAVPERSRANDCEN Special Report (SR) 82-4, *Preliminary objectives for single-ship antisubmarine warfare team training exercises*, October 1981; NAVPERSRANDCEN Technical Report (TR), *Developing an objectives-based team training course in active sonar antisubmarine warfare*, in press; NAVPERSRANDCEN TR, *Developing team performance measures*, in preparation.

Program dynamics are:



HANDBOOK FOR TESTING IN NAVY TECHNICAL TRAINING

Need

Instructional development in the Navy is guided by the Interservice Procedures for Instructional Systems Development (ISD). This process focuses on training objectives which are specifically tied to tasks that will be required on the job. In this process, tests during training should be developed to measure student progress toward these objectives. Such tests are called "criterion-referenced" tests. In addition, tests should also diagnose each student's specific areas of weakness so that remedial or supplementary instruction can be given.

Recent studies on the use of the ISD model for instructional development, however, suggest that ISD does not contain adequate procedures for developing criterion-referenced or diagnostic tests. A 1978 survey of Navy curriculum development personnel showed that test development was an area in which there was a strong need for specific "how-to-do-it" procedures. Therefore, an effort was undertaken to develop a detailed handbook and workbook for developing criterion-referenced test items and tests.

Approach and Results

The Handbook for Testing in Navy Schools was based on earlier NAVPERSRANDCEN work in the field of testing. The handbook was field tested extensively in a series of workshops designed to obtain information from potential users about the utility of the procedures. The handbook was revised to incorporate information obtained from the workshops and comments by Chief of Naval Education and Training (CNET) personnel.

The handbook begins with an introduction to testing in Navy technical training and the process of construction of test items and tests. The second chapter introduces a classification system for training objectives and test items adopted from the Instructional Quality Inventory (IQI). Objectives are classified according to two dimensions: the type of task the student is required to perform (remembering information or using it to perform a task), and the type of content to be learned (facts, categories, procedures, rules, or principles). This classification is important, because different types of objectives have different testing requirements; for example,

different item formats and numbers of items will be required depending on the task and content type of the objective. The classification system also helps to ensure that items consistently and adequately test the objectives they are supposed to measure. The next three chapters give detailed guidance on the development of test items to measure each of the various types of objectives. The final chapter of the handbook contains procedures for pilot-checking tests, and statistical procedures for evaluating test items and tests.

The handbook is designed for use by Navy curriculum developers and course instructors. The accompanying workbook provides detailed practice examples and feedback on the procedures contained in the handbook.

Utilization

The handbook and workbook will be used by the Chief of Naval Education and Training. Forthcoming revisions of CNET's testing and curriculum development guidance and instructions, *Procedures for Instructional Systems Development*, NAVEDTRA 110A, will endorse the handbook for use throughout the Naval Education and Training Command.

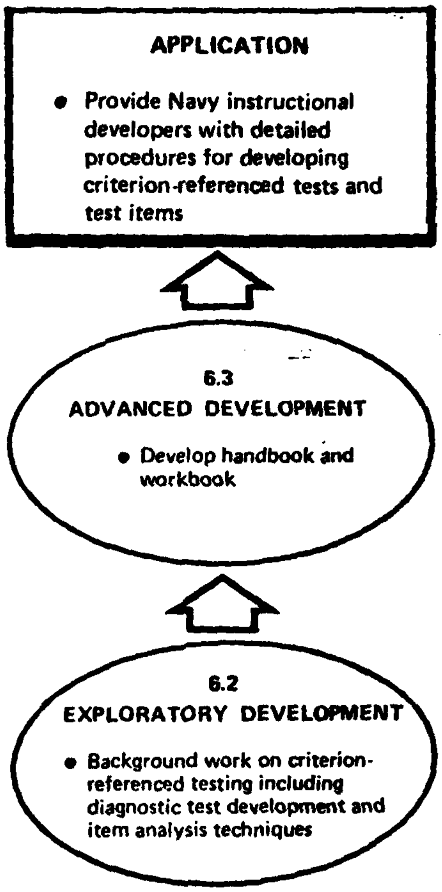
Impact

Use of the handbook will improve the quality of tests used during training, and it therefore offers the potential to improve substantially the quality of Navy technical training in general. The handbook will help ensure that the Navy's criterion-referenced testing program reflects the performance requirements of the operational community.

Research and Development Notes

The handbook was developed under Program Element 63720N, Education and Training, Project Z1175-PN Training System Design and Management, Subproject 05 Improved Effectiveness in Course Design, Delivery, and Evaluation. It was sponsored by the Deputy Chief of Naval Operations (Manpower, Personnel, and Training) (OP-01). Funds for its final development and tryout were provided by the Chief of Naval Education and Training. The responsible researchers were Drs. John A. Ellis and Wallace H. Wulfeck, II., NAVPERSRANDCEN, San Diego, CA. The handbook is based on work covered in a number of NAVPERSRANDCEN reports; specifically, those describing the Instructional Quality Inventory (Special Reports 79-3, 79-5, 79-24, and 80-25) and criterion-referenced tests (Special Report 80-15 and Technical Notes 80-8 and 81-16). The handbook and workbook are documented in Special Reports 83-2 and 83-7, respectively.

Program dynamics are:



SIMULATION IN MAINTENANCE TRAINING

Need

Operational equipment has traditionally been used as a primary means for providing training and hands-on practice for electronics equipment operation and maintenance tasks. The cost and complexity of these hardware systems has increased significantly over the past two decades and it is becoming exceedingly difficult for the Navy to acquire actual equipment trainers (AETs) in the quantities required to meet existing technical training needs. The problem is further complicated at the initial skill training level where AETs in use are relatively old and rapidly approaching obsolescence.

In July 1976, the Office of the Chief of Naval Operations stated a requirement for a Class "A" Electronics Equipment Maintenance Training (EEMT) system. The requirement noted the deficiencies associated with using actual equipment as a primary training medium. It also established performance goals for a flexible low cost training system that would ultimately lead to a minimum 50 percent reduction in acquisition, operation and maintenance costs when compared to conventional hardware systems used in electronic-oriented *maintenance training*.

Approach and Results

The EEMT system prototype development effort was implemented in four phases. The first two project phases involved concept formulation, analyses of electronic equipment and training task requirements, and preparation of hardware specifications for a two-dimensional (2-D) and a three-dimensional (3-D) system component. A training pipeline analysis was conducted, and a life-cycle cost model prepared, to assist in planning and establishing baseline criteria for system implementation, test and evaluation. The Electronics Technician (ET) and Electronic Warfare Technician (EW) Class "A" Schools were selected as target users of the prototype system. Based on the results of electronic equipment and task commonality analyses, preliminary generic electronics training syllabi and lesson specifications were prepared. In addition, representative (actual) equipment syllabi for the AN/SPS-10 radar, AN/WSC-3 communications and AN/SLQ-32(V) electronic warfare systems were prepared to assist in determining the effectiveness of the training system as a supplement for installed AETs in the designated schools' hardware laboratories.

The figure below illustrates the 2-D trainer.

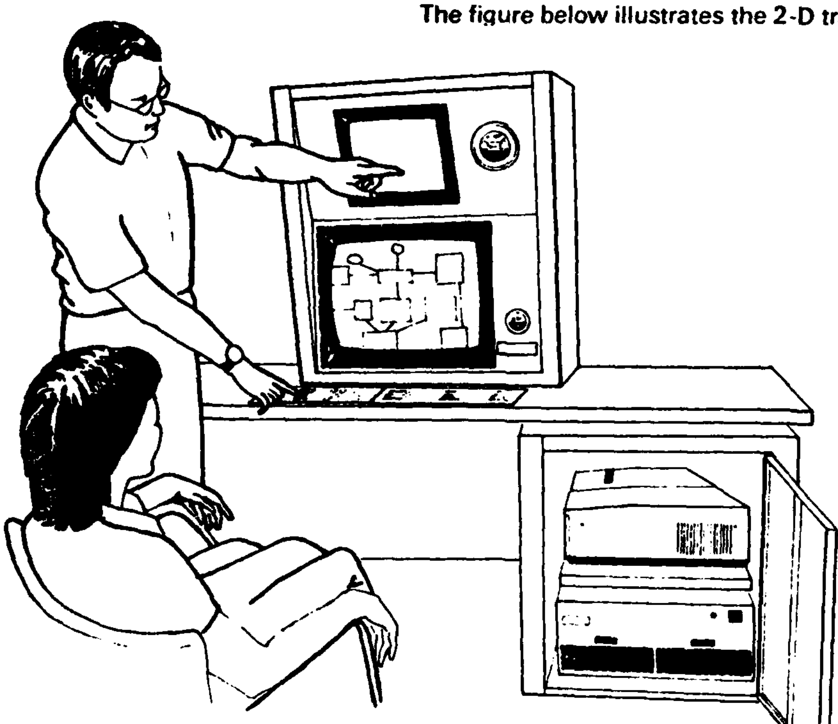


FIGURE: 2-D Electronic Equipment Maintenance Trainer.

Subsequent project phases involved hardware production, system software integration, lessonware development and implementation for system test and evaluation. A total of 37 of the 2-D trainer/simulators (Device 11B106) and one 3-D generic radar/communication system trainer were incrementally installed in the ET "A" School, Great Lakes. The 2-D trainer/simulators were systematically integrated into the existing AN/SPS-10 radar and AN/URT-23 communications tracks and are currently undergoing formal test and evaluation under the direction of the Training Analysis and Evaluation Group (TAEG), Orlando, FL. Preliminary test data for the AN/SPS-10 radar training track indicated that a 36 percent increase in student through-put and a performance gain of from 8 to 10 percent on final test scores on actual equipment has been achieved.

Implementation of the generic training syllabus using the 3-D trainer has been delayed as a result of ET "A" School curriculum changes and a subsequent shift of equivalent generic training modules to the Basic Electricity and Electronics (BE&E) Schools. Planning for 3-D trainer test and evaluation in the BE&E School, San Diego is currently underway. System testing in the EW "A" school was cancelled to allow for early implementation in the ET "A" School.

Utilization

The Chief of Naval Education and Training (CNET) is currently sponsoring the acquisition of forty additional 2-D EEMT trainer/simulators to be installed in Fire Control Technician (FT) Class "A" School. Plans for out-year buys include a total of approximately 130 devices to augment electronics-oriented Class "A" School installations and to support hardware specific Class "C" School training. Equipments identified for future 2-D EEMT applications include the AN/SPS-40, AN/SPS-49 and AN/SPG-55 radar systems; AIMS MK 12 IFF system; AN/WSC-3 and AN/WSC-6 satellite communications systems; and AN/SLQ-17 and AN/SLQ-32 electronic warfare systems.

Impact

The thrust of the EEMT system prototype development effort has been to design, produce, implement and test a state-of-the-art training system that would reduce dependence on the use of actual equipment trainers in electronics-oriented training courses. Initial ET "A" School utilization data suggest that this major goal has been achieved. The hardware system, which is essentially composed of off-the-shelf commercial equipment, is capable of simulating virtually any electronic or electromechanical system. It can also be easily adapted to a wide range of procedural and system troubleshooting training tasks. In keeping with the goals established by the requirement, the training system also represents affordable technology which can be purchased in quantity at the cost of a single major prime equipment system.

Of equal importance has been the parallel development of a series of flexible and transportable training, simulation, and user utility software programs. These programs, written in UCSD PASCAL, are independent of the trainer hardware system and can easily accommodate changes in individual trainer components. The software programs are also independent of the actual hardware systems being simulated on the trainer. Actual equipment simulations are represented as data files in the microcomputer and as stored images on a video disc. Simulation data bases and training scenarios are constructed using procedural formats designed for use by subject matter experts. Skills required for entering a data base onto a floppy diskette approximate those of using a typical word processing system. No computer programming expertise is required to use or fully implement the training system. Constructing a visual data base is somewhat more complicated but is well within existing video production capabilities of both the government and industry.

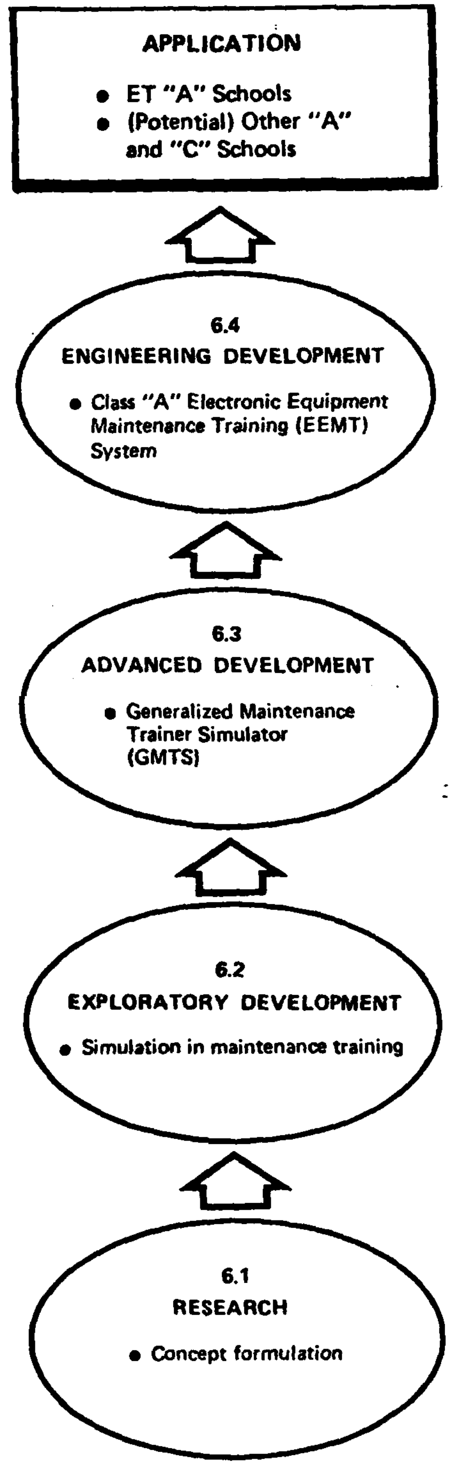
Research and Development Notes

This work was initiated in 1977 and will be completed in 1983. Funding was provided in Program Element 64703N, Training Devices Prototype Development, as Project Z0789-PN, Class A Electronic Equipment Maintenance Training System. The Navy Personnel Research and Development Center (NAVPERSRANDCEN), San Diego, CA, was the responsible laboratory, and the current principal Technical Reports (TRs), Technical Notes (TNs), and Special Reports (SRs) have been:

- Pine, S.M., Koch, C.G., and Malec, V.M., *Electronics Equipment Maintenance Training (EEMT) System: System Definition Phase,* NAVPERSRANDCEN TR 81-11, May 1981.

- Pine, S.M., Daniels, R.W. and Malec, V.M., *Device Test and Evaluation Plan for Electronic Equipment Maintenance Training System (Device 11B105)*, NAVPERSRANDCEN SR 81-19, June 1981.
- Towne, D.M., King, C.A. and Munro, A., *A Generalized Maintenance Trainer-Simulator: Development of Hardware and Software*, NAVPERSRANDCEN TR 81-9, April 1981.
- Wylie, C.D. and Bailey, G.B., *Electronic Equipment Maintenance Training System: Preliminary Design Options*, NAVPERSRANDCEN TN 79-3, October 1978.
- Advanced Technology, Inc., *Electronic Maintenance Training Equipment: A Comparative Analysis*, NAVPERSRANDCEN SR 82-24, May 1982.
- Mark, L., Kribs, H., Schuler, J., and Brown, J., *A Life Cycle Cost Model for an Electronic Maintenance Trainer*, NAVPERSRANDCEN SR 82-33, August 1982.

Program dynamics are:



TRAINING PACKAGE FOR THE CHEMICAL WARFARE DIRECTIONAL DETECTOR

Need

In response to requirements for chemical warfare (CW) defense, the Naval Surface Weapons Center (NAVSWC), Dahlgren, VA, developed the Chemical Warfare Directional Detector (CWDD)(AN/KAS-1). The CWDD is a passive infrared imaging sensor which provides U.S. Navy ships with the capability to detect and identify airborne CW nerve agents. In a secondary mission role, the inherent characteristics of an infrared sensor make the CWDD useful in low-visibility/night pilotage and area surveillance. Detection of personnel on the water surface (e.g., man overboard) can also be provided by the system. The figure illustrates the sensor unit, mounted at the railing.

The CWDD was sponsored by the Office of the Chief of Naval Operations as a Quick-Reaction project and has been approved for service use (ASU). It is now proceeding through fleet introduction. An instructional system was critical to support the CWDD's deployment.

Approach and Results

As with any new system, especially one such as the CWDD which is introducing to the fleet a relatively new technological device, the complete training support for installation, checkout, operation, and maintenance proved to be significant. The original plan was for a formal training curriculum which required three days of classroom instruction (Class "A" School level). However, to avoid any delay in training and to reduce the cost in training billets, classroom space, Temporary Additional Duty (TEMADD) time and funds for fleet personnel, and training materials, NAVSWC developed a complete shipboard training package.

The CWDD Training Package consists of an Illustrated Training Booklet (ITB) and three Chemical Warfare Video Training Tapes (VTTs) for detailed operating and maintenance instructions. The tapes are compatible with the ship's Closed Circuit TV systems.

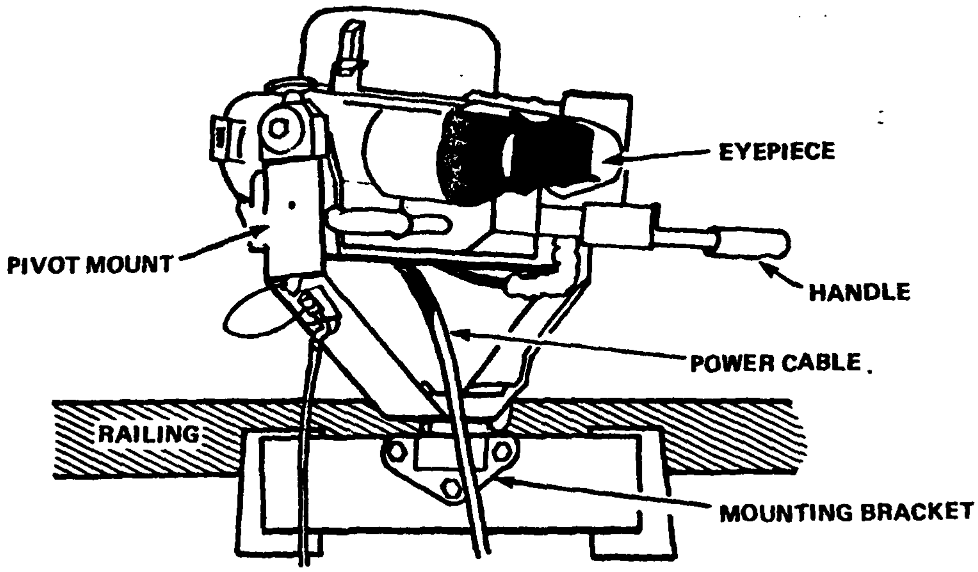


FIGURE: AN/KAS-1 Sensor Unit.

The CWDD Training Package, along with the Description, Operation, and Maintenance Instructions Technical Manual, was delivered with CWDD Installation Kits to the six ships selected for initial installation. NAVSWC CWDD project personnel conducted the deliveries, assisted ship's force with CWDD installation, and validated the Training Package.

The CWDD Personnel Qualification Standard (PQS) was written during the deliveries and validation.

Utilization

The ITB/VTTs and technical manual provide all information which would have been taught in three class days of "A" School instruction. The training is paced aboard the ship as convenient to the crew. The ITB is in "comic book" style, the tapes are readily usable, and the technical manual is brief and well illustrated.

Impact

The CWDD Training Package proved to be clear, complete, and effective. It gained unqualified acceptance from all levels of ships' personnel during installation and validation visits. Its use is scheduled by the ship and creates no adverse impact on shipboard training requirements. It complements the ship's training plans by providing a completely organized and structured package, requiring no additional preparation, for inclusion in a ship's Training Board schedule.

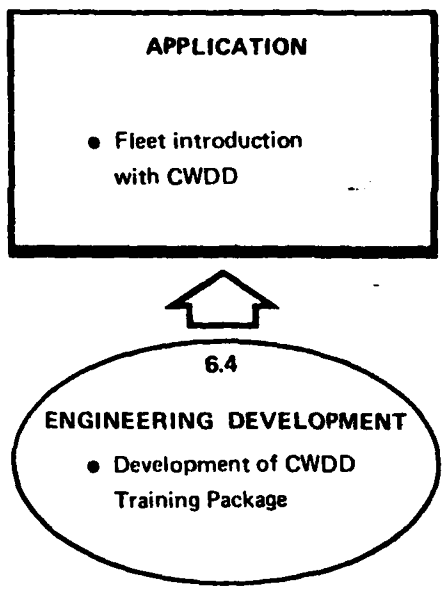
The CWDD Training Package and its shipboard implementation negated the need for expenditures for training billets, classroom space, TEMADD time and funds, and training materials costs.

Research and Development Notes

This project was supported in Program Element 64506N, Chemical Warfare Advanced Warning Counter-Measures Program. The responsible researcher was Mr. Stuart B. Herndon, Electro-Optical Systems Branch (N54), NAVSWC, Dahlgren, VA, (703) 663-7332. Publications include:

- *How to Use and Maintain the Chemical Warfare Directional Detector AN/KAS-1*, SW073-AA-TRN-010.
- *"CWDD, AN/KAS-1: Introduction,"* VTT #800158 DN.
- *"CWDD, AN/KAS-1: Installation, Maintenance, and Operation,"* VTT #800157 DN.
- *"CWDD, AN/KAS-1: Identification of Nerve Agent Clouds,"* VTT #800156 DN.
- *Personnel Qualification Standard for Chemical Warfare Directional Detector System.*

Program Dynamics are:



HUMAN FACTORS ENGINEERING

In the Department of Defense, human factors engineering is defined as the "Development of improved methods and technologies for the analysis, design, and evaluation of equipment and systems for safer and more efficient operation and maintenance."

The Navy needs equipment and support systems designed in such a way that people can do their jobs faster, more accurately, and more safely when they operate, maintain, or employ equipment. The Navy's research and development program in human factors engineering is involved in all systems, from their initial formulation to test and evaluation. The program develops procedures and technology that will be applied by practicing human factors engineering specialists in various development agencies and contractor firms.

Projects in this category include:

- **Parameters of Three-Dimensional Display Devices**
- **Target Classification Using Acoustic Transients**
- **Mission Operability Assessment Technique**
- **Human Factors Engineering of Software**
- **Automatic Microfiche Image Mounter**
- **Introduction of Electronic Delivery Devices for Display of Technical Information**
- **Forward-Looking Infrared Systems Requirements Manual**
- **Voice Input/Output for Combat Systems**

PARAMETERS OF THREE-DIMENSIONAL DISPLAY DEVICES

Need

An operational user faced with the need to appreciate the depth dimension of a visual scene on a two-dimensional (2-D) display resorts to successive views of different segments of those events or accepts slow computation of perspective graphics to illustrate that missing dimension. Two classes of three-dimensional (3-D) display technology, stereo-pair displays and volumetric displays, have been developed to provide the needed capability for real-time three dimensional displays, with the latter not requiring any devices to be worn by the viewer. Both technologies increase the amount of information that can be placed on a given viewing surface, enhance the perception of the structure of complex objects, depict with greater precision the spatial location of events or objects, and reveal the presence of planes and surfaces within a configuration of data points. Many operational applications are anticipated, such as remote viewing of workplaces when operating manipulators for underwater salvage and repair, disposal of explosive ordnance, reduction of clutter and integration of tactical displays in aircraft cockpits, vehicle control, reconnaissance, air-to-air refueling, fire control, weapon delivery, and more faithful scene-depiction in simulators.

Approach and Results

In basic research programs, perceptual issues on visual depth perception were studied and optimal characteristics for the design of the viewer-display interface with stereo-pair display techniques were ascertained. Functional relationships were derived on visual performance under varied task conditions: as shape and angular distortions occurred when the viewer was located elsewhere than the correct viewing point, when interference arose from the proximity of images in space, and when different types of identifying characteristics interacted within multidimensional displays. These studies demonstrated that a stereo-pair display system was a feasible approach. They showed in particular that the depth dimension was readily apprehended from these displays, and that distortion and interference could be corrected. They also defined the minimal features of the display elements so that design economies could be realized. The figure below illustrates a product of this technology.

FIGURE: Binocular Helmet-Mounted Display.

Utilization

The Naval Ocean Systems Center (NOSC)-Hawaii is exploring the ability of stereo-pair devices to support remote, underwater work-systems. At the Naval Air Development Center, advanced developmental studies are underway on the use of stereo displays that are helmet-mounted for use in both high-performance and rotary-aircraft operations. Several commercial firms are marketing stereo-display devices and there is an increasing interest in this type of technology for entertainment purposes. A 3-D display symposium was held in January 1982 that brought together academic researchers, military laboratory scientists, and program managers, to explore the implications and

utility of this display technology and its military applications. The consensus was that knowledge of visual performance and the development of 3-D display hardware was accelerating and that a feasible and useful system would soon be available. The design of suitable control devices, and perceptual studies with dynamic objects in space, are the next priority efforts and appropriate research programs are presently in progress.

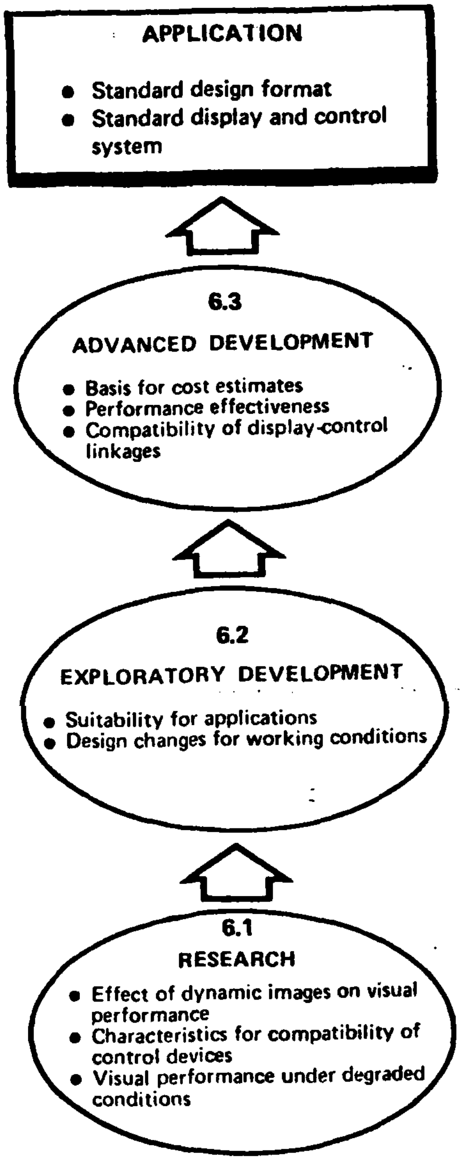
Impact

Design and development of an appropriate 3-D display device should provide an expanded capability over current 2-D devices. Performance effectiveness data reported by NOSC-Hawaii investigators with underwater teleoperator systems indicate that 3-D display capability provides an advantage of approximately 50 percent in performance times and accuracy over 2-D display representations. Computation time is markedly less for 3-D displays than for conventional 2-D representations which require the generation of perspective graphics to simulate depth and location.

Research and Development Notes

This program was performed under the sponsorship of the Chief of Naval Research by several contractors: Naval Ocean Systems Center-Hawaii, Dr. R. L. Pepper; National Research Council, Dr. R. T. Hennessy; SRI International, Dr. T. P. Piantanida; University of Michigan, Dr. R. G. Pachella; University of Pittsburgh, Dr. R.R. Rosinski; and Vanderbilt University, Dr. R. Fox. The projects were funded in Program Element 61153N, Defense Research Sciences, Subelement 42, Behavioral and Social Sciences, Project RR042-09, Engineering Psychology. The responsible program monitor was Dr. J.J. O'Hare, ONR (Code 442), (202) 696-4502. The projects were initiated in 1976 and will be completed in 1983. There are numerous technical reports available from each contractor as well as a symposium report, *3-D Displays: Perceptual Research and Applications to Military Systems*, National Academy of Sciences-National Research Council: Committee on Human Factors, September 1982.

Program dynamics are:



TARGET CLASSIFICATION USING ACOUSTIC TRANSIENTS

Need

Noise-reduction techniques have minimized steady-state emissions from naval platforms; as a result, acoustic transients have become a more productive means for classification of seaborne targets. Classification of underwater sounds has principally been conducted with the aid of visual displays, but an acoustic transient is not easily depicted as a visual presentation. Therefore, there is an increased operational need to employ the listening abilities of human observers. Hence, there is a requirement to define the target classification cues carried by brief (100 millisecond or less) sounds. These cues must be known in order that procedures for classification can be developed and the skills of human listeners enhanced. Further, knowledge of the characteristics that are important for classification can be used in efforts to reduce shipboard noise even further.

Approach and Results

Experimental studies have demonstrated that the critical feature for classification of an acoustic transient is its temporal or sequential structure. This feature is of even greater importance if the listener has knowledge about the rules that determine the structure of the sound; on the other hand, information about the context in which the sound was generated is advantageous only if there is a consistent structure to the sound. To maintain listener skill in target classification using acoustic transients, computer-based decision aids were devised and found effective. In fact, if such decision aids include a library of typical possible sounds, they can provide the listener with the ability to identify unfamiliar transients. The library can be based on six features: pitch, intensity, duration, rise-fall time, wave shape, and timbre.

To illustrate in a simplified form, the first figure below depicts the raw echo data as received. After electronic processing, a display can be created, such as the depiction in the second figure, to show echo structure.

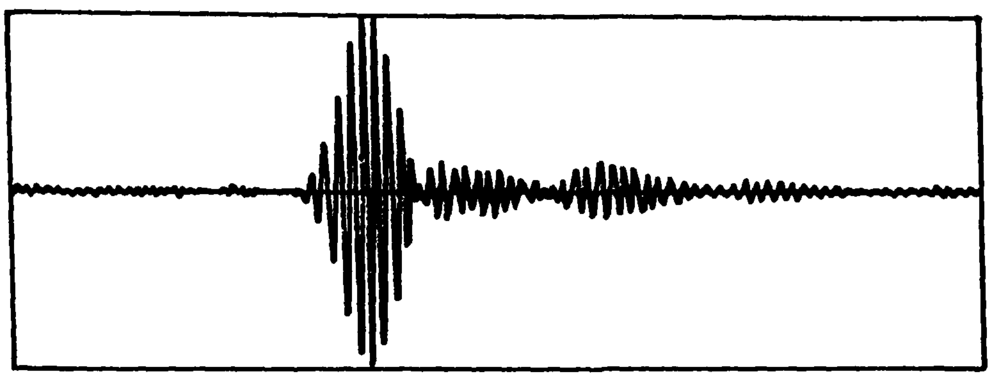


FIGURE: Raw Echo Structure.

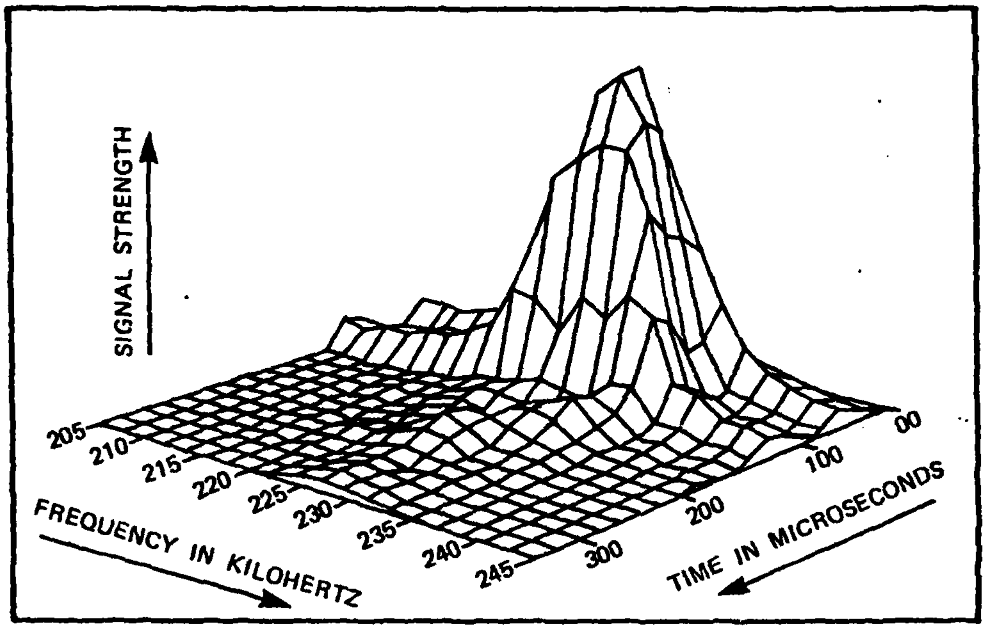


FIGURE: Echo Structure Display.

Utilization

The David Taylor Naval Ship Research and Development Center has undertaken an exploratory development program to reduce and eliminate transient acoustic signals radiated from a ship, particularly from its internal machinery, that may be used to confirm detection or uniquely classify the ship. The transient categories are being extended by the collection of operational underwater signals under the sponsorship of the Naval Material Command; a large library of acoustic transients will result. The Naval Underwater Systems Center-New London has undertaken an effort to synthesize acoustic transients that will be employed as a data base for fleet sonar-trainers.

Impact

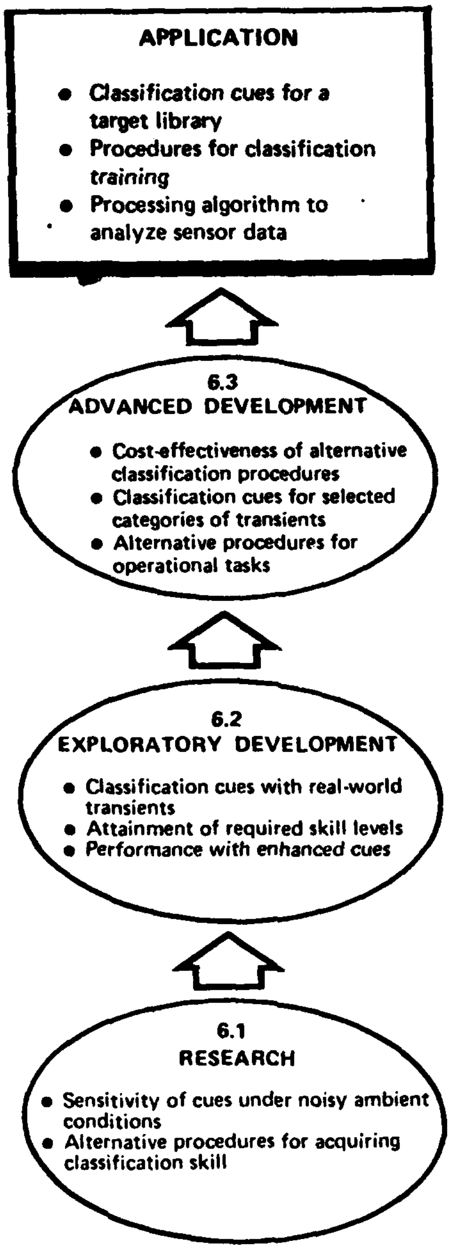
Design and development of signal-processing algorithms for the enhancement of the important cues that have been identified should provide an additional capability for classification of underwater signals beyond that available from steady-state sounds. Since transients are usually louder and intermittent, they should allow the human listener to be more vigilant in their recognition, and less likely to adapt to and consequently overlook their presence.

For ship-silencing purposes, human performance data on detection and recognition of transients should allow the development of a measurement standard for a wide range of transient types that could be applied to the specification of acoustically-acceptable shipboard machinery. In addition, the experimental procedures should permit the specification of methods for the evaluation of prototypes for new equipment and for training simulators.

Research and Development Notes

This research was performed at Catholic University, Washington, DC under the sponsorship of the Chief of Naval Research. The project was funded in Program Element 61153N, Defense Research Sciences, Subelement 42, Behavioral and Social Sciences, Project RR042-09, Engineering Psychology. The responsible program monitor was Dr. J. J. O'Hare, ONR (Code 442), (202) 696-4502. The principal investigator at Catholic University was Dr. J. H. Howard, Jr. The project was initiated in 1979 and will be completed in 1983. Numerous Technical Reports have been made available that define the role of sequential structure and context in listener performance (TR 80-14; TR 80-17; TR 80-19), the acquisition of classification skill (TR 81-6), and the feasibility of decision aids (TR 80-18).

Program dynamics are:



MISSION OPERABILITY ASSESSMENT TECHNIQUE

Need

As naval systems have become more complex, there has been a growing concern about the extent to which these systems are compatible with the capabilities of the individuals who are called on to operate them. One of the primary emphases has been on developing methodologies to evaluate systems to ensure that they are as compatible as possible to human capabilities and limitations. A major thrust in these efforts has been to develop methods that enable the operability of a system to be evaluated throughout the test and evaluation phase of the system acquisition cycle. It is a fundamental reality that during test and evaluation of new aircraft, the principal sources of information about how well the system is performing its function are the subjective evaluations of test pilots. Although these ratings are of great value in overall judgments of system operability, they do not systematically address all important components of aircraft subsystems. The objective of the Mission Operability Assessment Technique (MOAT) task is to develop a rating system and method of analysis which extract from raters' evaluations more accurate and more detailed information about the causes of specific system and subsystem operability problems.

Approach and Results

The MOAT approach depends on the development of scaling and mission system modeling. MOAT requests ratings on each task that an operator performs, rather than ratings on individual subsystems. Ratings reflect how difficult the task is and how well the system is designed to help the operator perform that task. The figure illustrates a

SUBSYSTEM EFFECTIVENESS IMPROVING				
Multiple tasks integrated	12	6	2	1
Design enhances specific task accomplishment	14	8	4	3
Adequate performance achievable (design sufficient)	15	9	7	5
Inadequate performance due to technical design, cannot compensate for sub-par performance	16	13	11	10
	Workload at critical level; Interference with A/C control; Compensation very excessive; Dangerous	Workload considerably higher than anticipated; Compensation high; Interference major	Workload slightly higher than anticipated; Moderate compensation; Minor interference	Workload as anticipated; No compensation; No interference

WORKLOAD IMPROVING

FIGURE: MOAT interval scale rating matrix.

scale rating used by test pilots to assess both pilot workload and technical effectiveness. Since each task is part of a mission phase, and is performed using some subsystem of the aircraft, task ratings can be combined mathematically to provide ratings of how well the system performs in a given mission segment or how well a subsystem meets its design goals. The technique for statistical combination of ratings is based on a theory of decision analysis called Multi-Attribute Utility Theory. The scale for ratings makes use of a method called conjoint measurement and its associated scaling procedures to transform the ordinal scales to interval scales. The product of the MOAT effort will be the scaling methodology and the technique for rating combination and analysis, implemented on a portable desktop computer. The technique is applicable to test and evaluation of any airborne system; output is designed to be used by test program managers or by design and evaluation engineers, depending on the level of output detail desired. For validation purposes, MOAT has been successfully applied to the A-7E aircraft.

Impact

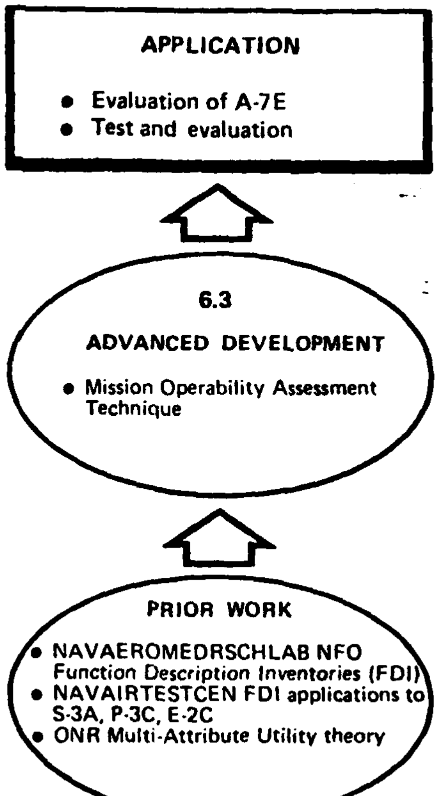
This project will result in a modern, relevant and standardized evaluation technology, adding a new dimension to Navy test and evaluation. Formal Navy test and evaluation efforts in the future will evaluate both hardware performance and the crewmembers' ability to operate effectively the system or subsystem during specific mission phases. Serious operability problems can be identified prior to full-scale production. MOAT will allow operability difficulties to be pinpointed to specific subsystem displays and controls. Workload itself can be related to quantitative standards of measurement. Eventually, operability of Navy weapons systems can be compared directly and objectively across dissimilar platforms.

Research and Development Notes

The development of MOAT draws on earlier work done in task analysis by the Naval Aerospace Medical Research Laboratory (NAVAEROMEDRSCHLAB) on Naval Flight Officer (NFO) Function Description Inventories; and on the application of Function Description Inventories to the S-3A, P-3C and E-2C aircraft, done at the Naval Air Test Center (NAVAIRTESTCEN). The decision analytic methodology uses Multi-Attribute Utility Theory developed under Office of Naval Research (ONR) sponsorship and adapted to the MOAT effort with the assistance of ONR.

MOAT was developed at the Pacific Missile Test Center (PACMISTESTCEN), Point Mugu, CA, 93042. LT Michael Lilienthal, USN (Code 1226), (805) 982-8981, was the responsible researcher. The project was identified as W1197-PN, Human Factors Engineering Technology for Test and Evaluation in Program Element 63701N, Human Factors Engineering Tecnology Development. It was initiated in 1977 and completed in 1982. Twenty-two Technical Reports, handbooks, and papers have been published or presented. The results of the successful validation on the A-7E aircraft, and a full description of MOAT, are provided in Helm, W.R., and Donnell, M.L., *Mission Operability Assessment Technique: A Systems Evaluation Methodology*, PACMISTESTCEN (TP-79-31), October 1979.

Program dynamics are:



HUMAN FACTORS ENGINEERING OF SOFTWARE

Need

Utilization of computers in the Department of Defense (DOD) has increased dramatically during the last ten years. DOD now employs computers in personnel management, data processing, command and control centers, weapons control, and many other applications. The common element in each of these applications of computers is that their functioning depends to a great extent on software. DOD has become greatly concerned about software because of its cost and the extent to which current weapon system functions depend on software. The yearly cost of software in DOD is over $9 billion. It is estimated that software development expenditures approach 70 percent of life-cycle costs of military computer systems, and will increase to 90 percent within five years. While these figures are only estimates, DOD software costs are very high and can be expected to increase. Another DOD concern is the increasing weapon system dependence on software. Over 115 major weapon systems depend on software for their success. While great technological advances have been made in software-based systems, little consideration has been given to the human operator who must use these systems. Increasingly, the limiting factor in weapon system operability and readiness will be the human operator's interface with weapon system software. This is particularly true during life-cycle support, when original software is modified to meet new requirements. Thus, the Navy has recognized the need to improve the Human Factors Engineering (HFE) of software.

Approach

The approach involves four thrusts related to selected steps in the Navy weapon system software change process, as depicted in the figure on the following page.

The principal focus of the first thrust, definition of change requirements, is to improve the generation and definition of software requirements as related to human performance requirements. At present, in this phase of the software change process there is little attention to such implications, even though in the typical case the validity of the software change can only be measured by system performance with humans as an element of the system. Clearly, human factors engineering should play a strong role in the definition of software changes. The purpose of this thrust is to provide methods by have which this can be facilitated.

With regard to the writing of performance specilittle fications, the focus of the second thrust is to develop software interface design guidance. Early applicability in the software change process, the format of to real-time weapon system computer interface displays, controls, and other man/machine interfaces, is determined in the software performance specification. Many computer interface design guides have been developed in recent years, but they requirements. Therefore, the objective of this thrust is to provide the needed design guide.

The third thrust of the project is to provide a better interface between the programmer and the software, through improved tools, documentation, and other support.

The final objective is to provide techniques for assuring that the developed software improves human performance in the weapon system.

Utilization

The tools, procedures, and materials developed in this program will be immediately used and evaluated by human factors engineers currently supporting weapon systems software support activities (e.g., F-14, EA-6B) at the Pacific Missile Test Center. This effort will also provide an approach and tools for incorporation of human factors into other software support activities (SSAs) at other facilities; the Naval Air Development Center and Naval Weapons Center are currently exploring involvement of human engineers in the SSAs for P-3 and F-18 software. The design guides developed in this effort will also be used in weapon system procurement contracts.

Impact

Implementation of this program will ensure that software developed for weapon systems maximizes human performance capabilities. Specifically, improved requirements analysis methods will significantly reduce the number of unnecessary or minimally necessary software changes to weapon systems, thereby freeing manpower to work on necessary software changes to weapon systems. The interface design guide will significantly improve the software-based displays and controls in weapon systems, thereby improving system effectiveness. Improvements in the programming process will significantly reduce software costs and ensure

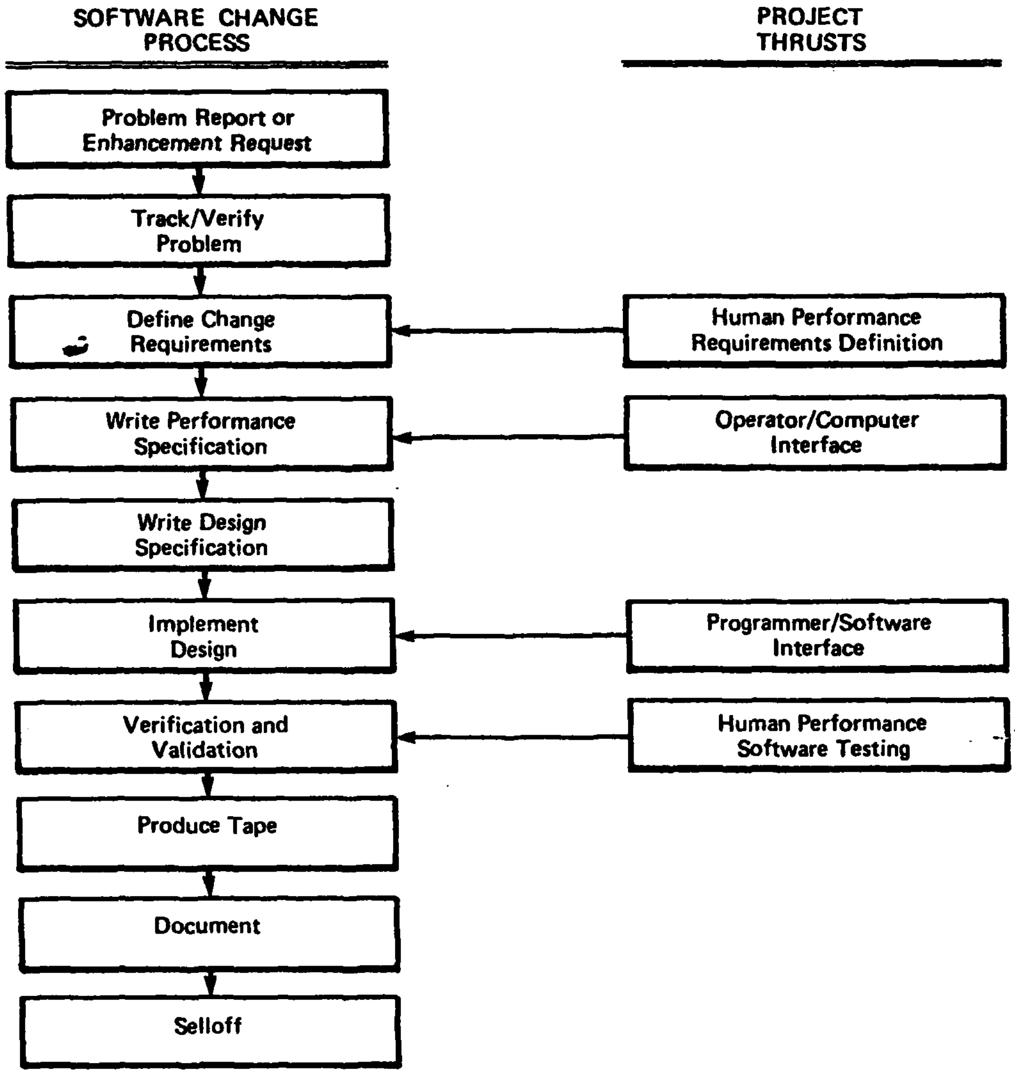


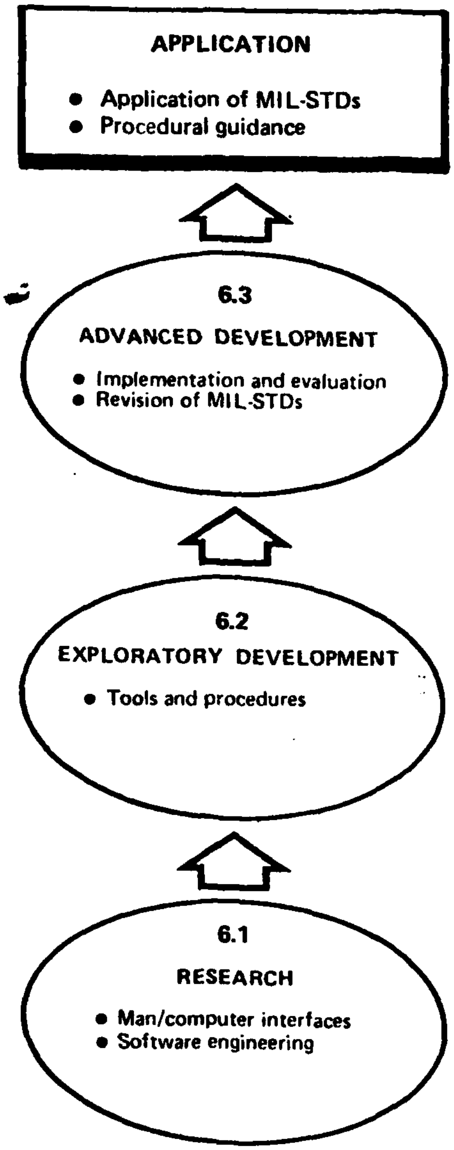
FIGURE: Project Intervention in Software Change.

timely incorporation of software changes to meet changing mission requirements. Finally, human performance tests will be included in software testing which will ensure that delivered software systems improve total mission success.

Research and Development Notes

This work is being performed at the Pacific Missile Test Center (PACMISTESTCEN), Point Mugu, CA, 93042, under the leadership of Dr. Richard A. Neetz (Code 1226), (805) 982-8981. The work was initiated in 1981 and is planned to continue until 1989. The more recent work has been funded in Program Element 62757N, Human Factors and Simulation Technology, Project WF57-525, Human Factors Engineering in Software Development. Nine documents have been published or are in preparation, the most recent in print being *Human Factors Engineering (HFE) in Computer Systems, Volumes 1 through 5*, Neetz, R. A., Ellingstad, V. S., Struckman, D., Prokop, L. S., and Overmyer, S. P., PACMISTESTCEN TR, January 1983.

Program dynamics are:



AUTOMATIC MICROFICHE IMAGE MOUNTER

Need

Since its operation began in 1974, the Military Personnel Records System (MPRS) at Naval Military Personnel Command, Washington, DC has controlled and administered the personnel records of all current and former members of the Navy and Naval Reserve. This semi-automated system maintains and updates the military personnel records in a microfiche format, then distributes the records to authorized users. However, MPRS is still labor intensive and subject to error. A candidate for improvement was the micro image mounting function. This function was done with a semi-automated device that relies on operator judgment to place the image in the correct frame on the right personnel record. The David Taylor Naval Ship Research and Development Center (DTNAVSHIPRANDCEN) was tasked to investigate new approaches to improve placement technique.

Approach and Results

Building on previous research and development efforts by the Rome Air Development Center, an Air Force image mounter was obtained. A contract was awarded by DTNAVSHIPRANDCEN to investigate adding additional automatic quality control checks into the equipment to provide positive comparison of the image to be mounted and the record. This would eliminate a long-standing problem of filing information on the wrong member's record. This was successfully done using a photographed Binary Coded Decimal (BCD) display which contained the social security number of the individual along the leading vertical edge of the image and matching it with the bar-code which is on the label of the microfiche. This feature was successful and is included in the delivered prototype mounter. The figure below illustrates the mounter.

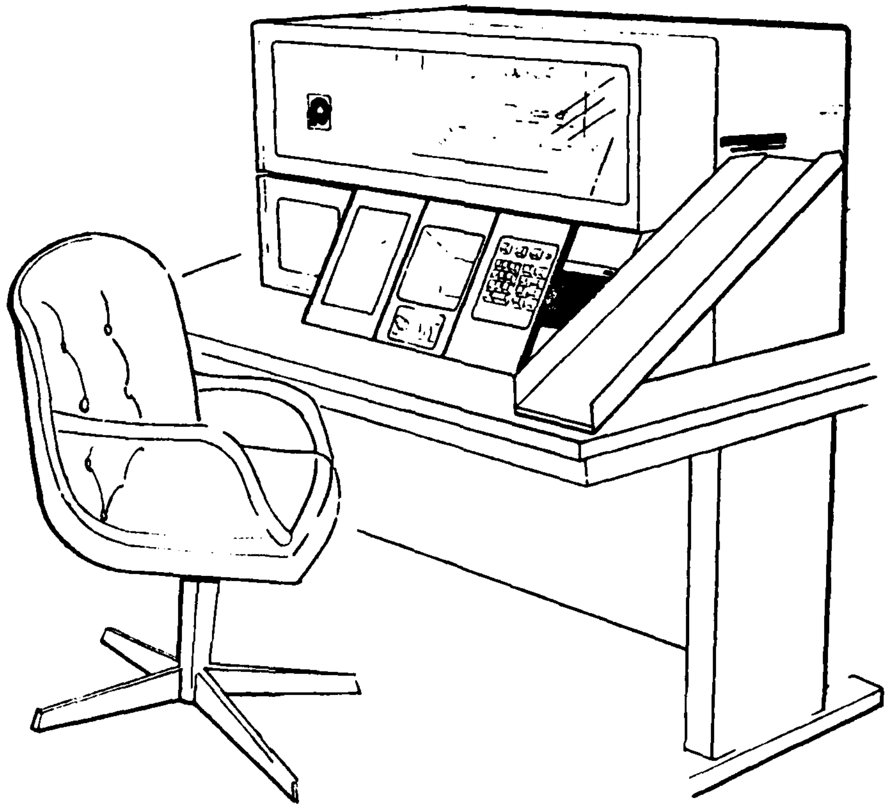


FIGURE: Image Mounter.

Another feature investigated and added to the prototype was a continual search of each record to locate open frames. Open frames are spaces embedded in already filled areas of the record. When viewing a record, open frames leave doubt in the user's mind as to whether data is missing or if the space was caused by system placement errors. The automated locator feature points out these discrepancies and allows the record researcher to correct the error. It also prevents this from happening in the future. A third area of investigation was an optional manual feed of microfiche records into the device, and override capabilities so the image mounters could be integrated into the MPRS independently of other components required to make the system fully operational.

Utilization

The mounter/certification unit prototype was delivered to Naval Military Personnel Command and procurement of ten additional units is in progress. These units add approximately 38,000 images daily to the personnel records. While there are no other known users of the equipment, the technology is available to approved government users.

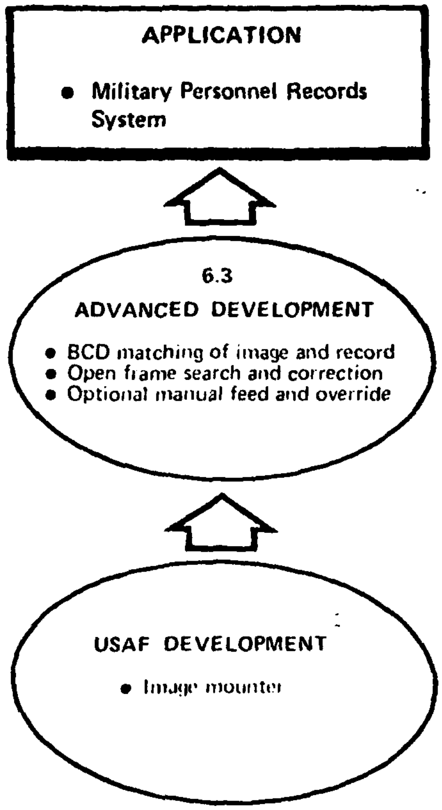
Impact

The semi-automated system has 19 mounters with 14 on line at all times. The new system will require 11. The benefit from this effort is improved service to users of the personnel record such as selection boards, the Board for Corrections of Naval Records, detailers, the Veterans Administration, and the naval member.

Research and Development Notes

This work was sponsored by the Deputy Chief of Naval Operations (Manpower, Personnel and Training) (OP-01), and conducted by the David Taylor Ship Naval Research and Development Center. It was identified as Project W1584-PN, Improved Personnel Records System, in Program Element 63707N, Manpower Control System Development.

Program dynamics are:



INTRODUCTION OF ELECTRONIC DEVICES FOR DISPLAY OF TECHNICAL INFORMATION

Need

The David Taylor Naval Ship Research and Development Center is developing a Navy Technical Information Presentation System (NTIPS). It consists of procedures and advanced technology for the definition, acquisition, generation, mastering, replication, distribution, delivery, and control of technical information (TI) used in the operation, maintenance, training, and logistic support of weapon systems.

One element of this system is the use of portable and work center electronic display devices to present TI. Previous attempts to introduce microfilm into the Navy as a medium for presenting TI resulted in poor acceptance and underuse of the TI. Because of this history of resistance to change, it was apparent that introduction of electronic display devices as part of NTIPS would require careful attention to developing devices which were useful to maintenance personnel and which would attract use.

Approach and Results

Aware of the resistance which users had shown to microfilm, the Navy Technical Information Presentation Program initiated a human factors study on resistance to change (RC), specifically oriented to electronic devices for delivering TI to users through a video type of display in their work environments. The objectives of this study were to examine portable and work center delivery device designs to identify design variables related to RC, and to minimize or eliminate RC by proposing design improvements and methods of introduction, use, and support.

The NTIPS approach was based on the assumption that certain work characteristics are associated with job satisfaction. Maximum use must be made of factors designed to produce these characteristics. In summary, RC tends to occur when:

- *Users find the system difficult to operate* (ease of use)
- Users are not able to perceive any benefit to themselves (benefit)
- The use of the system does not get the job done (utility)
- The system is not operable or otherwise available (availability)
- The system is not introduced adroitly or with adequate training (familiarity).

Three types of factors were investigated in this study. They were:

- Fifteen work activities of TI users, such as:
  - — Preparing a work schedule
  - — Determining the work location
  - — Performing the work
  - — Returning to the Work Center
  - — Completing 3M forms
- Forty-seven variables of delivery systems, such as:
  - — Voice synthesis capability
  - — Type of screen
  - — Printer capability
  - — Keyboard input
  - — Keypad input
  - — Voice recognition input
  - — Print font
  - — Intercharacter spacing
  - — Battery duration
  - — Notes, cautions, warnings
  - — System response time
  - — Image generation
  - — Type of TI content (maintenance, operations, training, logistics)
  - — Color
  - — Line width for text
  - — Motion
  - — Contrast
  - — Prompting
- Eleven characteristics having to do with job satisfaction, such as:
  - — User expectancies
  - — Competition
  - — Opportunity to use valued skills
  - — Opportunity to learn
  - — Feedback
  - — Autonomy.

This approach produced seventy-nine recommendations for the design of the NTIPS TI delivery system. Sixty-two of these recommendations are unique to particular work activities in the fleet. Seventeen recommendations relate to all work activities (e.g., use of color, motion) or to off-duty use of TI (e.g., games).

Typical recommendations dealt with such matters as:

- Providing to the technician information about the availability and working order of such items as test equipment, spares, and consumables
- Automating the means by which technicians "sign out" for accountable equipment

- Automating the collection of maintenance data
- Providing a means for local analysis of maintenance data to explore matters of local organizational interest.

Utilization

The TI design recommendations are being taken into account by the developers of NTIPS in:

- Establishment of system design principles
- Developing methods of system introduction (e.g., use to satisfy job requirements and also provide training opportunity)
- The design of the TI itself (e.g., insertion of enrichment messages among procedural instructions).

Impact

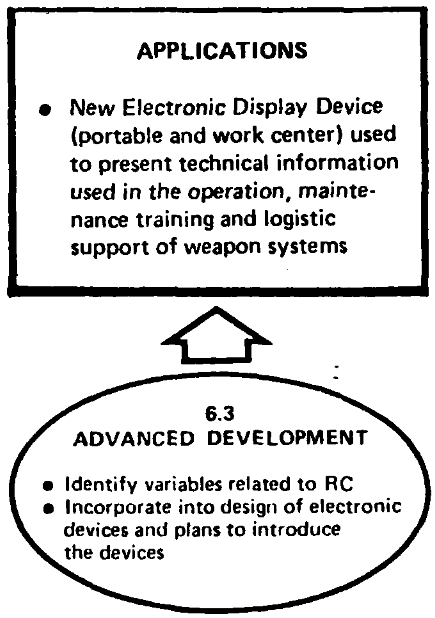
In recent years, fleet operators and technicians have shown a tendency to ignore TI required for execution of system-related tasks involving system operation, maintenance, and logistic support. As a result, system availability has decreased significantly. Potential improvements in the maintenance field are as shown below, if high quality and usable TI can be presented in a manner so that users at all levels will rely on it.

- Reduction in use of spare parts: 30%
- Reduction in Mean Time To Repair (MTTR): 40%
- Reduction in maintenance man-hours: 33%
- Reduction in fault isolation time: 35%
- Reduction in formal training: 50%-80%

Research and Development Notes

This work was funded in Program Element 63727N, Navy Technical Information Presentation System, under Project W1032-PN, The Navy Technical Information Presentation System. The responsible researcher was S.C. Rainey (Code 1803), (202)227-1372, AUTOVON 287-1372, David Taylor Naval Ship Research and Development Center (DTNAVSHIPRANDCEN), Bethesda, MD, 20084. The work was performed by T.J. Post of BioTechnology, Inc., Falls Church, VA, in FY 1981-1982. A Technical Report will be available: Post, T.J., *Recommendations to Avoid Resistance to Change in Introduction of Electronic Delivery Systems,* Contract N00600-80-D-B563, BioTechnology, Inc., 1983, in preparation.

Program dynamics are:



FORWARD-LOOKING INFRARED (FLIR) SYSTEM REQUIREMENTS MANUAL

Need

The Navy buys and operates Forward-Looking Infrared (FLIR) sensor systems for its tactical aircraft. These systems provide a significant long-range, non-radiating, imaging capability which can operate at night or when atmospheric conditions do not permit direct visual or television target acquisition. FLIR can be used when active radar search is operationally unwise.

In the course of procurement as well as utilization and planning, predictions about operator performance and the performance of existing or proposed FLIR systems for specific Navy missions are required. Although computer models which provide predictions do exist, they require substantial knowledge of the models, their input requirements, and especially their assumptions and limitations. Many of those facing the decisions do not have the access to this model information or the special skills required.

Hence, the need exists for a simple, transparent, accessible method of matching FLIR capabilities to missions, useful to users who are human factors specialists, operational requirements specialists or mission planners.

Approach and Results

The approach to providing the needed capability involved the development of a two-part manual.

- Part I provides a set of structured worksheets which can provide a quick look at the match between a specific FLIR system (existing or hypothetical) and a specific mission. Results take the form of Range versus Probability curves, for one or more levels of target discrimination. This simplified analysis requires a minimum of input detail and a minimum of technical depth on the part of the user. This simplification is achieved at the cost of some flexibility and precision.

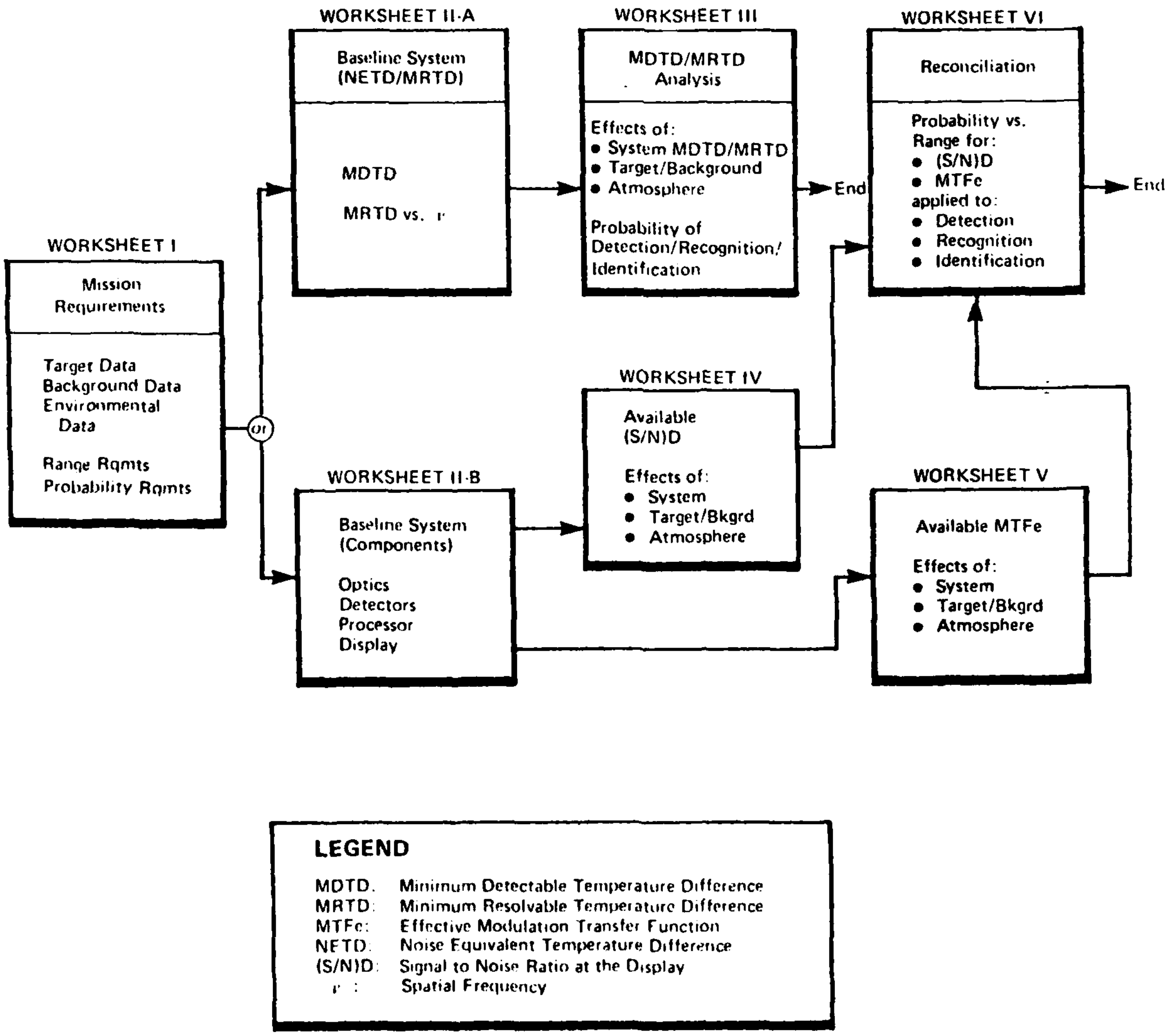


FIGURE: Flow of FLIR system requirements manual.

- Part II consists of treatments, in greater depth and detail, of the topics covered in Part I. These back-up sections:
  - — permit the user to examine the sources of the algorithms and charts used in Part I;
  - — provide means of circumventing some of the limitations built into Part I;
  - — provide greater insight into the sources of system limitations, and guidance in the choice of options to overcome them.

Each worksheet has numbered lines with blanks to be filled in by the user. A line-by-line commentary is provided to assist the user, somewhat in the pattern of Internal Revenue Service Income Tax forms.

Two parallel sets of worksheets are included, to be chosen by the user, depending upon the level of system definition available. A flow diagram of the worksheet structure is illustrated in the figure.

Utilization

The manual is currently in final review at the Naval Weapons Center (NWC), preparatory to publication.

To date, draft editions of the manual have been used to validate the procedures against the existing data base of FLIR system performance.

Requests for the kind of capability represented by the manual have come from other elements of the Targeting Division of NWC aircraft program offices and from other Navy installations (e.g., the Naval Training Equipment Center).

Impact

Reduced costs through use of the FLIR System Requirements Manual will result because an evaluation of a FLIR system for a proposed mission can be done by the user in a matter of 2 to 4 hours; there will be no computer time, no intermediary specialists, and no waiting for computer printouts. If a mismatch is found, a method for determining the type of system change which would improve the performance is also a part of the manual. Sensitivity of the outcome to factors such as weather, time of year, geographic region or flight profile is also made explicit by the procedures in the manual.

Payoff may also be realized by avoidance of costs of FLIRs with more expensive requirements than called for by a given mission, or less operational effectiveness than expected. Applications for the manual in mission planning are also expected. Preparation of a set of algorithms for insertion in the Joint Munitions Effectiveness Manuals (which currently have no FLIR capability) is underway, based upon the foundations of the FLIR System Requirements Manual.

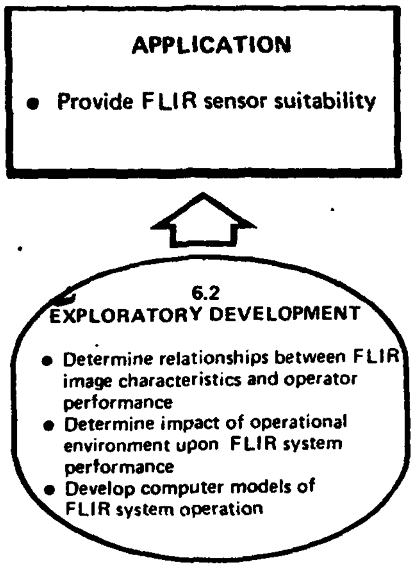
Research and Development Notes

The performing agency for this effort has been the Targeting Division, Human Factors Branch (Code 3152) of the Naval Weapons Center, China Lake, CA, 93555. The responsible invididual was Dr. C.P. Greening, Code 3152, (619) 939-3167. Funding was provided in Program Element 62757N, Human Factors and Simulation Technology, originating in the Naval Air Systems Command.

The work which led to this manual was initiated in 1972 under a series of contracts between the Naval Weapons Center and various contractors (including Hughes Aircraft, General Research Corp., and Rockwell International), and funded in part by the Target Acquisition Working Group (TAWG) of the Joint Technical Coordinating Group for Munitions Effectiveness (JTCG/ME), and in part by the Naval Air Systems Command. These studies and other related work provide a basis for estimating the image characteristics required to perform specific detection or recognition tasks, and the means of relating these image characteristics to sensor characteristics and mission performance.

The manual has been presented to the Military FLIR community through publication of a summary in the Proceedings of the January 1983 Infrared Information Symposium (IRIS) Specialty Group on Infrared Imaging. Two technical publications are NWC TP 6139, *Target Acquisition and Image Quality*, C.P. Greening and G.C. Savage, September 1979 (Unclassified), and NWC TP 6418, *FLIR System Requirements Manual*, C.P. Greening, June 1983 (Unclassified).

Program dynamics are:



VOICE INPUT/OUTPUT FOR COMBAT SYSTEMS

Need

Combat System Architecture as it exists today involves a rather large, complex information network. It also requires the ability to access information rapidly, make a decision and then take action. The man-to-machine communications required to access this information and facilitate the decision-making process are built upon a rather simplistic and rigid control language. Generally this language is implemented via push buttons, keyboards, trackballs and footpedals on consoles equipped with displays of such poor quality and resolution that they would be totally unacceptable for a home video game.

Voice technology (both recognition and synthesis) is being examined as a potential method for reducing errors, relieving operator workload and increasing the overall efficiency of the system. Proper operation of consoles at the speed demanded by high technology warfare may require that both hands be used to control simultaneously the various buttons, keys, and trackballs, while manipulating a footpedal and monitoring several displays. Due to the quality of console displays, all of these functions must be performed in a very dimly lit space. To perform these duties, a large number of highly trained operators are necessary so that fatigued persons may be quickly replaced.

Voice recognition is a method of inputting data which is compatible with the performance of other tasks; eyes and hands are free to do other things. The accuracy and reliability of a voice interactive system is totally unaffected by inadequate lighting. It is also believed that use of the voice may help reduce some of the stress involved in completing the required tasks.

Recognizing the potential of voice technology in military applications, a Voice sub-group was formed under the DOD Human Factors Engineering Technology Advisory Group (HFE TAG). The purpose of the Voice Sub-TAG is to serve as a forum for the exchange of ideas and information pertaining to the development and application of voice technology.

Approach and Results

Because it has been identified as an eyes-hands busy system, the MK 68 Gun Fire Control System (GFCS) was chosen for an initial demonstration of voice input and output (I/O). Communications with the MK 68 are normally performed through the MK 167 console, which is a panel of buttons, lights and displays. An operator pushes a button on the console and a signal is then sent to the AN/UYK-20 computer. Upon completing the desired computation, the computer sends a message back to the user in the form of either a display or warning light on the console.

The addition of a voice recognizer and a synthesizer to the system allows the operator to make inputs to the computer verbally or use a combination of verbal and manual commands. Several manual operations can be combined into a single voice command (e.g., to "scrub console" manually could require ten or more separate button actions). Visual feedback is provided via the console as usual, with the addition of a limited amount of voice feedback.

The feedback from the synthesizer is limited because the operator is already functioning in a noisy environment and constant verbal information would probably be lost or ignored. The synthesizer is employed when a verbal command to the computer is unclear (e.g., "Did you say ...") and also to add "visibility" to a warning message that the operator might not see immediately (e.g., "Target Out of Range," which is displayed above the normal area of focus).

A MK 68 Voice I/O demonstration was performed in an environment with a noise level comparable to that found aboard a ship. This was done in order to gain information concerning control of noise and distortion and to prepare for actual shipboard usage. A voice recognition terminal was then taken aboard the USS BELKNAP (CG 26). A small group of seamen who had no prior experience with voice recognition devices and little to no experience with computer programming were selected to experiment with the recognizer. After a brief explanation of how the recognizer works, the men learned how to use the recognizer with a high degree of accuracy. Results show that little training is necessary in order to use voice equipment.

While this experiment demonstrated the feasibility of using voice technology in a combat system, it also showed that using voice as the only means of communicating with machines may not always be the best method. Combining voice technology with advanced graphics technology and a variety of input devices will probably produce the optimum approach. Also, using voice recognition to replace simple button pushing may fail to utilize the technology to its fullest potential.

Utilization

Voice I/O is already being utilized in several areas for training purposes. A natural follow-on would be to allow people who have trained with voice technology to use it in their jobs. Both recognition and synthesis rely on digitalization of the verbal commands; the digitized commands may be transmitted and used directly as input to the computers with greater accuracy than can be achieved by manually inputting a command that was issued verbally.

In addition to applying voice technology to individual console positions, it can be used in conjunction with other technologies to give the Ship Weapons Coordinator (SWC) or Tactical Action Officer (TAO) immediate access to information from multiple consoles and data bases. Also, combining recognition and synthesis with other technologies, such as large screen displays, video discs, and pointing mechanisms may give the TAO or Commander the ability to query rapidly the various computers for any significant information, make a decision, and implement it immediately. Voice technology thus has potential for enchancing the decision-making process.

Voice is particularly well suited for use in areas where there is dim lighting, or where keyboards, displays and manuals may be awkward.

Impact

Using voice technology in the most beneficial manner will require additional research in the areas of human factors engineering, natural language processing, and artificial intelligence. Additionally, operational requirements and performance criteria for a voice-interactive system remain to be defined.

Since voice communications are widely used within combat systems, it appears that little training would be required for voice recognition and synthesis systems. A voice interactive system appears to require less training than a totally manual system. By reducing operator workload, an actual manpower decrease may also be realized.

By using voice technology, input to the computers may be made directly by Commanding Officers as well as the various console operators, and all

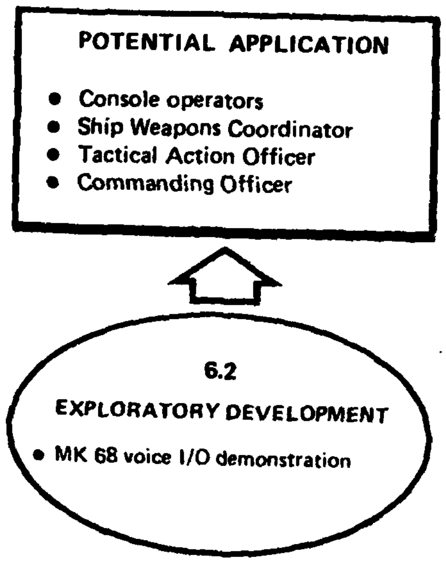
feedback can be immediate. The anticipated results include a reduction in errors, time to perform a task, and manpower. An increase in system efficiency should also be realized.

When the cost of recognition and synthesis hardware is compared to the cost of other I/O devices and coupled with reductions in manpower and training requirements, a voice interactive system is expected to be very cost effective.

Research and Development Notes

This work has been performed in Program Element 62766N, as Independent Exploratory Development Task 2F66-212, in FY 1982-1983 and continuing. The responsible researcher has been Mary Gail Pierpont, Naval Surface Weapons Center (Code N32), Dahlgren, VA, 22448, (703) 663-7458. A pending publication is Naval Surface Weapons Center Technical Note 83-73, M.G. Pierpont, February 1983.

Program dynamics are:



SIMULATION AND TRAINING DEVICES

In the Department of Defense, this area of People-Related RDT&E involves the "Development of cost effective training equipment and technology that produce the needed performance for operation and maintenance of military systems."

The Navy needs training devices and simulators for several purposes: to improve readiness through realistic exercise; to reduce training costs; to increase safety during practice of dangerous activities; and to reduce the destructive impact of training activities on the environment.

Projects in this category incude:

- **Anti-Submarine Warfare Simulation Research Facility**
- **Augmented Visual Carrier Aircraft Recovery System (AVCARS)**
- **Diagnostic Performance Measurement for Carrier Landing**

ANTI-SUBMARINE WARFARE (ASW) SIMULATION RESEARCH FACILITY

Need

The investigation of simulation techniques for ASW training is motivated by a need to enhance the initial training of ASW operators and to provide practical means by which experienced operators can maintain their skills. The complex skills required for ASW specialists dictate a continuous pipeline for training new operators and a facility capable of simulating a realistic operational environment for refresher training of experienced ASW operators. The need for improved training is supported by operational requirements from the air and surface ASW communities to improve acoustic propagation models, to improve table-top ASW simulators such as Device 14E38 for the AN/SQR-18A, and to improve refresher training for analysts of low frequency acoustic spectra. Demonstrably, the need is evident in a $400 million ASW trainer improvement program ongoing at the Naval Training Equipment Center (NAVTRAEQUIPCEN) over the next five years.

Current technology uses expensive simulators in conjunction with weapon system hardware to perform ASW training. Cost constraints limit the amount of formal training that can be provided. The development of low-cost simulators for training in specific ASW areas such as tactics and spectrum analysis will provide a level of training that is otherwise unattainable using the few large simulators available.

When completed, the ASW Simulation Research Facility will encompass a complete system to test and evaluate ASW training approaches, ASW ocean and target models, and ASW displays; and to develop hardware and software requirements for modification of ASW training systems.

Approach and Results

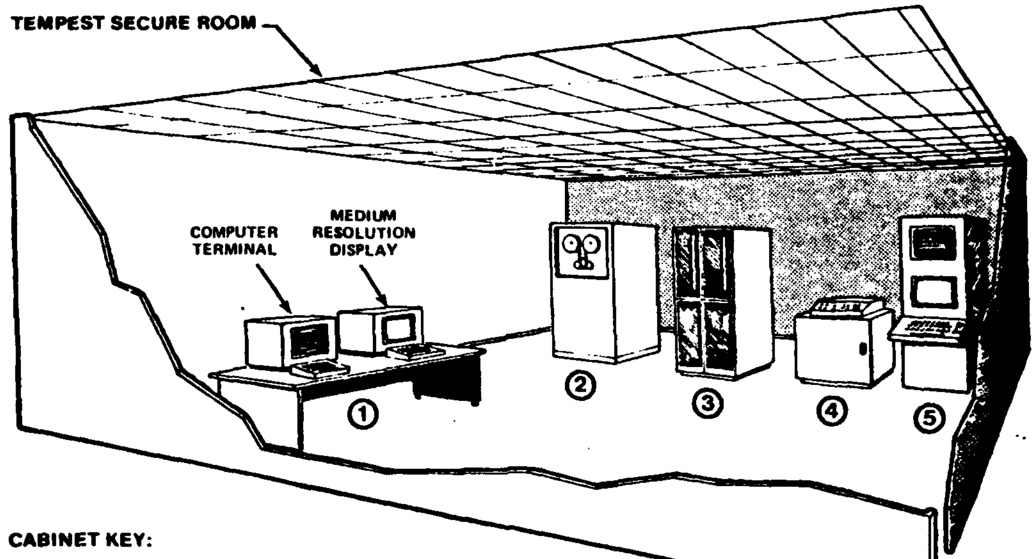
Development of the ASW Simulation Research Facility will require procurement of a computer system and display devices suitable for simulation of ASW displays. A separate computer facility is needed because of the security classification of the data used in ocean and target modeling. The ASW displays being developed cannot be generated on a time-shared system accessible to many users. The research to support the development of the simulation facility is being focused on ocean modeling, target modeling, and display systems. The accompanying figure is an artist's conception of the facility.

Modeling acoustic propagation loss in the ocean environment is a difficult process. The different models now in use present standardization and support problems. Equally difficult is the problem of interfacing training devices using different ocean models. Different models, utilizing different theoretical approaches and different computer software, will produce different results for the same ocean environment. This project is concerned with the design and development of a common ocean model for all ASW training devices.

The acoustic or target modeling effort will investigate two methods for providing realistic targets for training. A target model based upon use of available intelligence data will be developed. This will support training applications where it is necessary to generate selected training scenarios or simulate interaction between trainee decisions and target response. For applicatons where data from acoustic tapes of actual contacts can provide suitable training, methods will be developed to transform the acoustic data into spectral data in digital form. This technique will provide realistic data for a low-cost acoustic trainer for classification.

Finally, state-of-the-art technology will be evaluated in order to develop ASW displays which will present realistic intelligence to the operator trainee. High and medium resolution display systems will be studied; microcomputers will be evaluated for generating and driving low-cost ASW displays; and engineering specifications will be developed for an improved display system.

All of the above effort will be combined in the ASW Simulation Research Facility to demonstrate and evaluate the new models and display capabilities. The facility will provide a test bed for new ASW training concepts prior to initiating any procurement action. Modular development of software will provide a quick response to questions that arise during conceptual development or procurement. The development of the facility will be coordinated with all ASW projects at NAVTRAEQUIPCEN through an ASW Steering Committee.



CABINET KEY:

① INSTRUCTOR'S STATION	② DIGITAL COMPUTER (VAX 11/780)	③ ANALOG TAPE UNITS	④ ACOUSTIC PROCESSOR (AQA-7)	⑤ OPERATOR STATION
• PROBLEM INITIALIZATION • PROBLEM CONTROL	• OCEAN MODEL • TARGET MODEL • CONTROL FUNCTIONS • SIGNAL GENERATION		• GENERATION OF LOW FREQUENCY ACOUSTIC DISPLAYS	• HIGH RESOLUTION DISPLAYS • OPERATOR CONTROLS

FIGURE: Artist's Conception of ASW Simulation Research Facility.

Development of low-cost simulators for training in specific areas such as spectrum analysis and ASW tactics will be a major application of the ASW Simulation Research Facility. The hardware complement selected will allow demonstration of state-of-the-art applications to table-top acoustic trainers, generic operator consoles, and instructor aids for problem generation and control.

Utilization

A concept for the ASW Simulation Research Facility was developed which meets the requirement for a pseudo real-time system and the need for a secure system to operate with classified acoustic intelligence. Based on the concept, a prototype facility has been established to demonstrate the performance of ocean and target models in providing effective ASW displays for training. Six different ocean models have been modified to run on the NAVTRAEQUIPCEN VAX 11/780 computer. Hardware and software have been added to the existing facility in order to stimulate its acoustic processor to produce spectral outputs for discrete frequencies. The ASW Steering Committee has developed an ASW Simulation Research Plan and Roadmap, and the Facility has established a support interface with ongoing ASW acquisition projects. Of immediate concern is support for the Device 20B5 Pierside Trainer; Device 14E27A Acoustic Processor Operator Team Trainer; and the Device 14E35 SQQ-89 Operator Team Trainer. Support has been planned for the 14E37/14E38 Table Top Proficiency Trainers and 14A12 Team Trainers in FY 1984 and the 20A66 Multiple Ship ASW Team Trainer in FY 1985. In addition, the Facility has been utilized to develop and provide specifications for the ocean model to be utilized in the 14A12 Team Trainer when it comes on line. The Facility was also utilized to modify the Sonar In-Situ Mode Assessment System (SIMAS) Program for incorporation in the 14A12 ocean model. SIMAS provides ocean prediction data from a data base which includes the North Atlantic, North Pacific, Indian Ocean, and Mediterranean Sea.

Impact

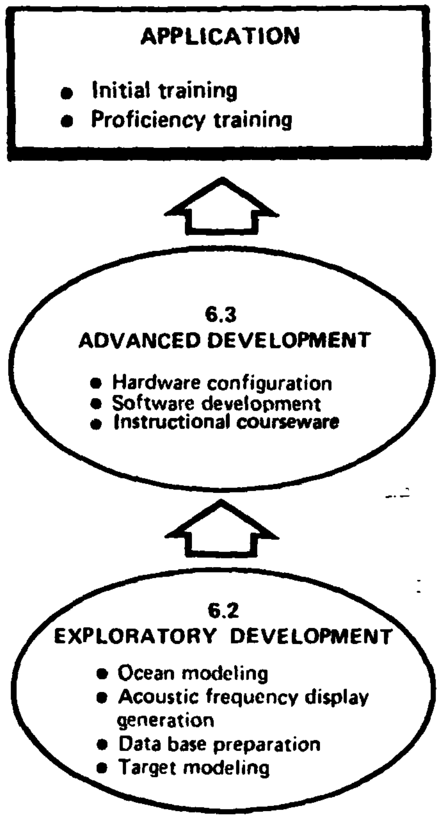
Although this project is supporting ongoing acquisition programs by providing an ASW technical base for training, its main objective is to explore new ground in ASW simulation technology for training. The Facility will provide the necessary computer hardware and software to demonstrate a low cost "hands-on" acoustic trainer concept for initial and mid-level ASW skills training. The technical base developed will support future trainers for shipboard refresher training and instructor station development for ASW training . In addition, the results obtained from evaluating ocean and target models and various ASW displays will be used to determine hardware and software requirements for future ASW training systems.

The potential of the Facility as a test bed for ASW systems research and evaluation has already been proven. The Facility was used to demonstrate the feasibility of entering a computer program via an inexpensive line in lieu of a floppy disc. The demonstration refuted a contractor's statement and request to add an expensive floppy disc system to a piece of equipment under development.

Research and Development Notes

This project is being conducted by the Naval Training Equipment Center (NAVTRAEQUIPCEN), Orlando, FL, 32813, with funding provided in Program Element 62757N, Human Factors and Simulation Technology. It combines work initiated under two earlier projects, Development of Computer Models for Multiple ASW Trainer Applications, and Simulation Techniques for Basic ASW Operator Training. The effort was initiated in FY 1982 and is scheduled for completion in FY 1985. The project leader at NAVTRAEQUIPCEN is Dr. Leonard W. Healy (Code N-74), (305)646-4491/5415. TRACOR, Inc., 6500 Tracor Lane, Austin, TX, 78721, and Sanders and Associates, Daniel Webster Highway, South, P.O. Box 868, Nashua, NH, 03061 have been the contractors. There are no published publications at this time.

Program dynamics are:



AUGMENTED VISUAL CARRIER AIRCRAFT RECOVERY SYSTEM (AVCARS)

Need

The development of AVCARS was initiated in response to pilot observations during night carrier landing that the pilot knows consistently where the aircraft is during an approach, but does not have an instantaneous prediction of where the aircraft is going. Carrier pilots have adapted to this problem with varying degrees of success by developing rigid discipline to scan the indicators used in an approach, greater reliance on "seat of the pants" and Vertical Speed Indicator (VSI), and simple hard work to develop confidence in their abilities. Nonetheless, aviation statistics indicate reduced boarding rates and increased aircraft accident frequency at night, reflecting the need for additional carrier landing aids for night operations. The need for a prediction of future position, i.e., vertical descent rate cueing, was determined to be a requirement, and an improved carrier landing system was defined as an adaptation of the Fresnel Lens Optical Landing System (FLOLS) to display glideslope descent rate cueing.

Approach and Results

FLOLS provides primary glideslope displacement information to a pilot making a carrier approach to landing. The array of lenses and lamps provides a virtual image which appears to the pilot as a single light, dubbed the "meatball," located behind two horizontal datum bars. As the aircraft moves above or below the ideal glideslope, the meatball is seen through higher or lower Fresnel lenses to give the appearance of moving vertically above or below the datum bars. For a carrier approach, the pilot, on final, attempts to follow a designated glideslope by keeping the meatball level with the datum bars. The displacement information provided by FLOLS is helpful but less than optimum. Because the meatball displays only displacement errors, there are substantial lags between incorrect control inputs and subsequent FLOLS error information. A rate-of-change error must exist for some short period of time before it produces a perceptible displacement. Since the pilot is more directly in control of rate than displacement, it follows that the pilot could correct the rate error, if aware of it, before a substantial displacement developed. Although the need to improve the FLOLS display was recognized, it had remained essentially unchanged since its introduction into the fleet in the mid 50's. Two factors impeded a change to the FLOLS display; first was the possibility of introducing ambiguous information into the display, and second was the lack of a low-cost practical means of generating and displaying rate information.

When the problem and concept were discussed with researchers at the Visual Technology Research Simulator (VTRS), Naval Training Equipment Center, it was recognized that aircraft position from the carrier could be very accurately calculated and that visual technology was available to display rate-of-change information. Accordingly, VTRS personnel proposed that the proposed adaptation to FLOLS be evaluated in VTRS before proceeding with modification of fleet equipment and fleet evaluation. Given approval, VTRS personnel modified the computer-generated FLOLS image display in the simulator to incorporate two vertical light arrays appearing as bars or arrows extending up or down from the inside ends of the datum bars to provide a display of rate-of-change. The following figure illustrates.

Two approaches were developed to drive the arrows up or down to provide rate information. The first, designated the RATE display, drove the arrows up or down depending on whether the meatball was moving up or down. The second, designated the COMMAND display, drove the arrows up or down in proportion to the difference between the actual and the ideal descent rates so that null indications from the arrows would return the pilot to or maintain position on the glideslope. The arrows extended up when the descent rate was too low and down when it was too high. While on glideslope, indications from both displays were identical.

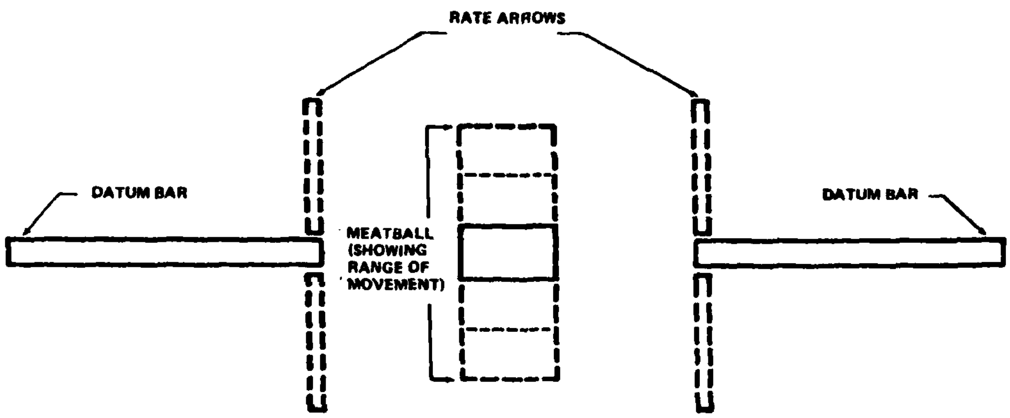


FIGURE: AVCARS Modified FLOLS Display.

The RATE display was proposed as a means of unburdening the pilot of the need to estimate the rate of ball movement while still scanning the FLOLS, lineup cues, and Angle-of-Attack indexer. The COMMAND display was proposed as a means of further unburdening the pilot of the need to decide how quickly to return to the glideslope. It also permitted the pilot to concentrate mostly on the arrows thereby lessening the problem of combining information from diverse display elements. No clear preference for either configuration could be established, so both were evaluated, as well as the standard FLOLS (CONVENTIONAL) display.

The final results indicated the COMMAND display was better than both the RATE and CONVENTIONAL displays, with the RATE display tending to be less effective than the COMMAND display but better than the CONVENTIONAL. Approach performance with the COMMAND display was more stable and accurate. This assessment was considered statistically reliable and substantial. Both COMMAND and RATE displays were less effective at touchdown, which was attributed to the sensitivity of the arrows. Overall, the data substantiated the fact that a rate-of-change display as represented by the VTRS COMMAND display could aid glideslope tracking to a greater extent than expected.

Utilization

On the basis of the successful evaluation conducted on the VTRS at NAVTRAEQUIPCEN, an existing FLOLS was modified for shore-based feasibility demonstrations at the Naval Air Test Center (NAVAIRTESTCEN), Patuxent River, MD. During the period 22 January through 19 February 1981, a total of 20 actual flights (night and day) were conducted at the NAVAIRTESTCEN. Initial test results indicated the AVCARS provided valuable sink rate cues which enabled the pilot to avoid large glideslope errors. Useable AVCARS cues were available at ranges up to 1¼ miles at night with proportional cues (i.e., pilots were able to discern small changes in the magnitude of arrows) available from at least ¾ mile. The AVCARS cues permitted the pilots to "lead the meatball" and thus make corrections for aircraft sink rate before the ball moved. Based on the qualitative results of the shorebased evaluation, shipboard testing was recommended and approved to confirm the shore-based data, evaluate the AVCARS under operational conditions, and optimize system parameters.

Successful shipboard testing was conducted on board the USS DWIGHT D. EISENHOWER (CVN 69) during the period 28 May through 1 June 1981. A total of 94 passes were made, 48 day and 46 night. The EISENHOWER memo summarizing the tests stated, "AVCARS provided valuable sink rate cues which enabled the pilot to avoid large glideslope errors..." Pilots were able to correct to optimum glide path with minimal overshoot.

Impact

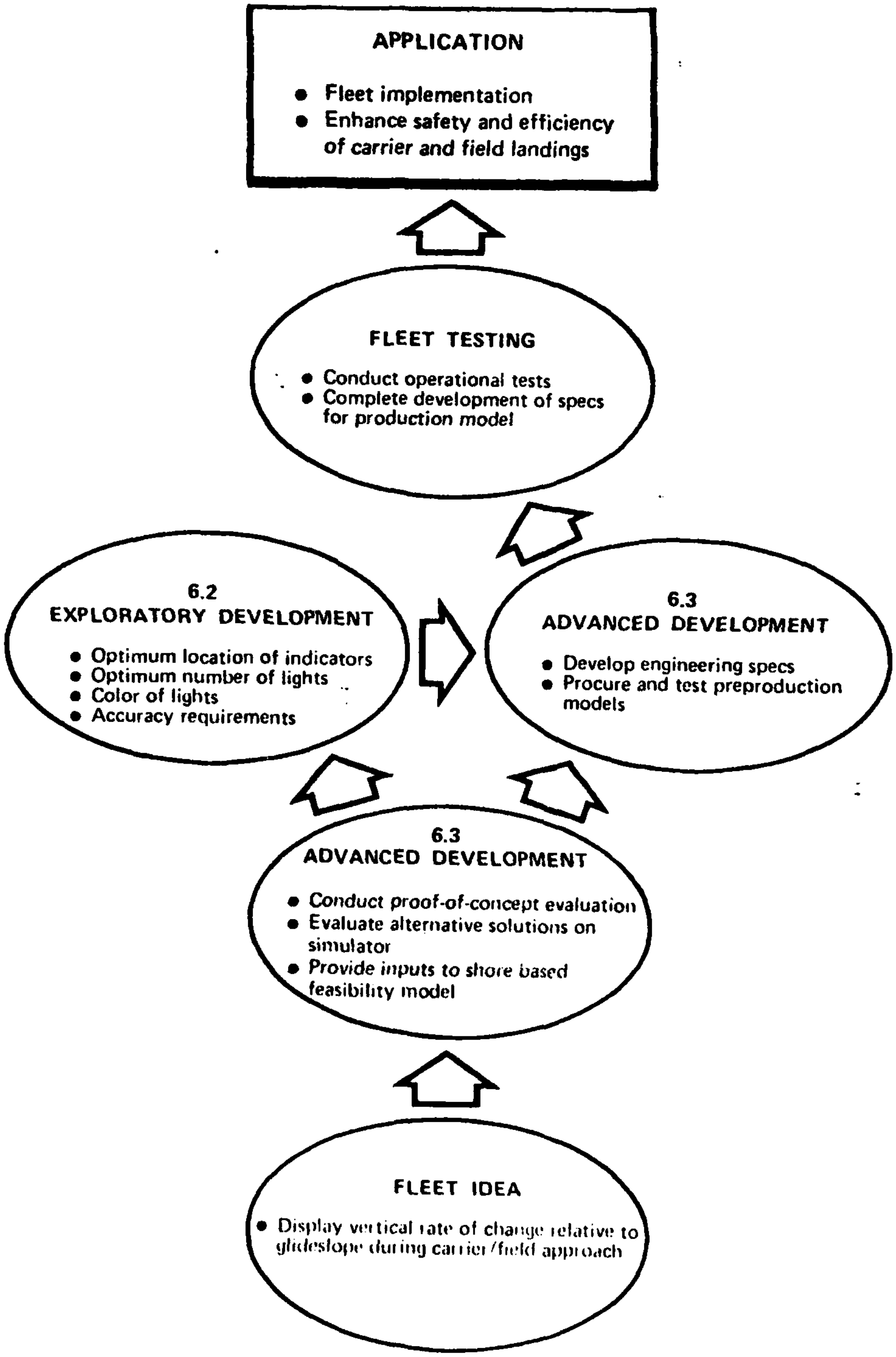
Fleet testing has shown an average reduction in glideslope error of 50 percent "in the middle" and 40 percent "at the ramp" when compared to the standard FLOLS. This translates into the increased boarding rates and reduced carrier landing accident rates which were identified in the Needs paragraph. The consensus of pilots who have flown the operational tests of AVCARS was that valuable and useable cues were provided. When asked to identify problems with AVCARS their comment was, "None!"

As a result of fleet evaluation, three preproduction models are being prepared by the Naval Air Engineering Center for reliability and environmental testing and further operational testing. A final system design has been completed and production award is anticipated in FY 1983 with fleet introduction in FY 1984. Unit cost is projected at under $100K. Initial fleet units will utilize the AN/SPN-42 radar for glideslope tracking. Other all-weather sensors have been tested for use in glideslope tracking, and results are being evaluated. First indications are positive for these higher performance versions, but unit costs would increase.

Research and Development Notes

This project was initiated in October 1979; operational evaluation is continuing. It was conducted at the Naval Training Equipment Center, Orlando, FL, 32813, by Mr. Walt Chambers and Dr. Stan Collyer (Code N-732). Contractors were General Electric, Daytona Beach, FL, and Canyon Research Group, Orlando, FL. Funding for the evaluation on the VTRS was provided in Program Element 63733N, Training Devices Technology, Project W1200-PN, Visual Technology Research Simulator. The final report is Kaul, C. E., Collyer, S. C., and Lintern, G., *Glideslope Descent Rate Cueing To Aid Carrier Landings*, NAVTRAEQUIPCEN Technical Report IH-322, October 1980. It should be noted that LT C. E. Kaul originated the concept as a result of his first night carrier landing experience, and participated in the project throughout.

Program dynamics are:



DIAGNOSTIC PERFORMANCE MEASUREMENT FOR CARRIER LANDING

Need

Carrier landings are an integral part of the mission capabilities of several aircraft communities. However, the boarding rate, glideslope control, safety factors, and other performance indicators of night landings are generally inferior to daytime performance for both Fleet Replacement Squadron students and fleet pilots. The increased likelihood of a student having to be retrained due to night disqualification can delay and even prevent entry of otherwise qualified pilots into the fleet. In addition, pilots being retrained consume fuel, trainer time and other resources.

The two primary training devices available for carrier landing training are the aircraft used during Field Carrier Landing Practice (FCLP), and Night Carrier Landing Trainers (NCLTs) such as those in use by the A-7 and A-6 communities. In a typical FCLP "bounce" period, the Landing Signal Officer (LSO) grades and records several comments on each of the 10 to 12 landings or passes made by each of the 10 to 12 replacement pilots. In the past, management of landing performance data was entirely manual and very time consuming. As a result, it was not feasible to provide detailed diagnoses of landing problems or trends for any individual pilot.

Approach and Results

The objective of this project is to develop a preprototype, computer-based, diagnostic debrief aid for use by LSOs in pilot carrier landing training and proficiency maintenance. The application consists of providing LSOs with information from an automated performance measurement system in order to improve pilot training during Carrier Qualification (CQ) training. The major concept is that training media are integrated between the aircraft and the training device (e.g., NCLT). The approach is to optimize trainer utilization based on an analysis of landing problems experienced in actual aircraft. The landing problems are analyzed from LSO remarks (not voice calls) made during FCLP in preparation for actual carrier landings. The NCLT is used with the FCLP to prepare students for the carrier.

The automated performance measurement system, called Automated Performance and Remedial Training System (APARTS), is illustrated in the following figure.

APARTS incorporates a number of fundamental principles of learning, motivation, and visual perception, in such a way as to organize and display information in formats that enhance user acceptance. Some of the resulting characteristics are:

- Individualized diagnosis of student landing problems in the aircraft. Diagnostic information is organized and summarized in a way the instructors understand. In addition to providing new information and formats, APARTS also performs all of the administrative performance record keeping tasks for the instructor.
- Almost immediate knowledge of diagnostic results.
- Provision for prescriptive remedial actions in the NCLT to correct diagnosed problems.
- Individual trend information so students and instructors can identify consistent or inconsistent changes in problems over the course of training.
- Normative data from which individual progress and achievements can be compared with performance by other students, aircraft types, environmental conditions, etc.
- Feedback display in an easy to process visual mode.
- Hardcopy printout of data for student use.
- User-friendly automated system which is easy to use by the student or instructor, prompts the user in conversational language, corrects user mistakes, cannot be hurt by the user, is small and portable, and maintains privacy of student data through controlled access.

Results obtained during the evaluation of the APARTS concept in the A-7 Fleet Readiness Squadron (FRS) showed that use of the system contributed to improved glideslope control and night carrier landing boarding rates. Additionally, potential student disqualification was identified by student performance trend analysis as early as the fifth FCLP training period. APARTS diagnostics were helpful in determining the remedial training required for the successful completion of carrier qualifications, thereby reducing the number of

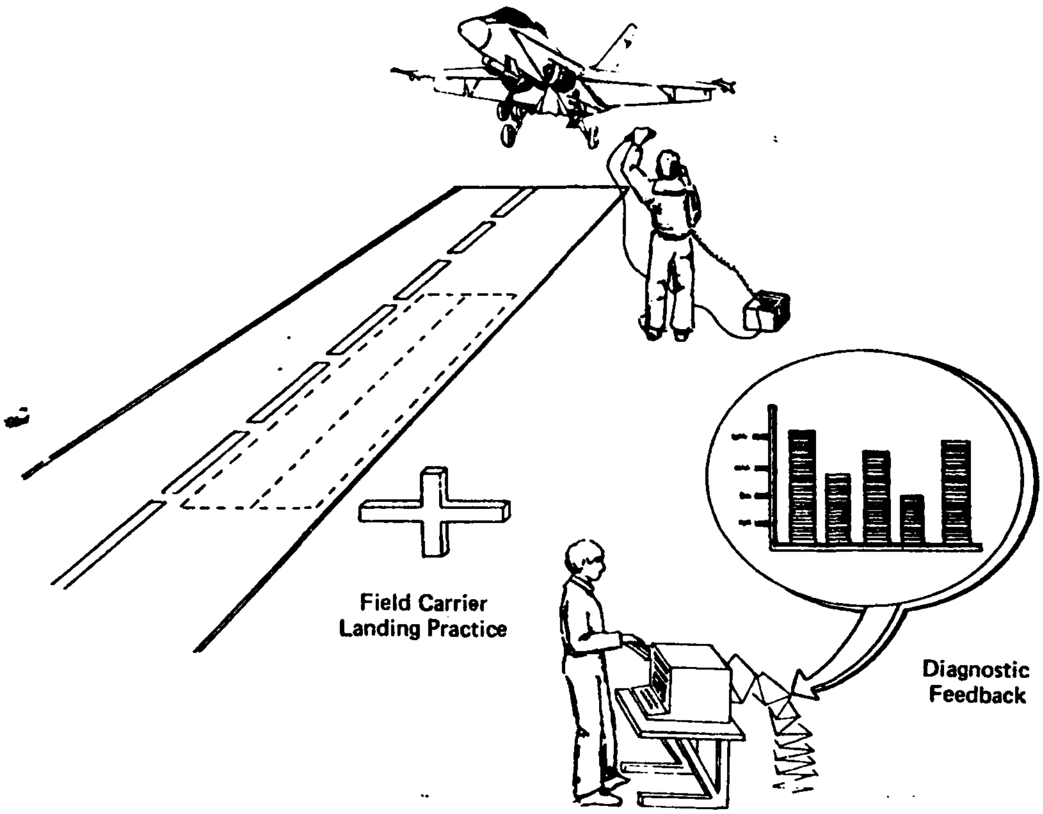


FIGURE: Automated Performance and Remedial Training System (APARTS).

recycled students. Similar results are occurring in field evaluations at A-6 and F-14 FRSs.

A modified APARTS performance analysis could be used effectively in student LSO training, since LSOs develop individual trends much the same as do pilots. LSO trends, such as slow detection of lineup error and slow determination of critical wave off points, can be documented through performance data analysis during training in the NCLT and in the existing LSO reverse display simulator. Use of modified APARTS should result in the grooming of an LSO who is more capable, much earlier.

Utilization

As a stand-alone LSO training aid, APARTS will be applicable to all carrier aircraft and to all flight simulators with carrier landing capability. Initially, feedback is needed most to aid pilots transitioning to high performance fleet aircraft. Eventually all squadrons, carriers and air wings will have APARTS capabilities. Specific carrier capable aircraft include: A-4, A-6, A-7, AV-8A, C-1, C-2, EA-3, EA-6, E-2, F-4, F-14, F/A-18, RF-8, S-3, T-2 and VTX. Specific carrier landing capable simulators include: 2F112, 2F122, 2F110, 2F119, 2F103, 2F95, 2F92A, and 2C63.

A data base of normative landing problems for LSO use is a potential by-product of this effort. The data base will describe normative landing trends experienced by different aircraft types, student categories, and training environmental conditions.

Potential payoffs of APARTS include:

- Decreased aircraft fuel costs due to reductions in student recycles.
- Increased carrier safety through increased proficiency.

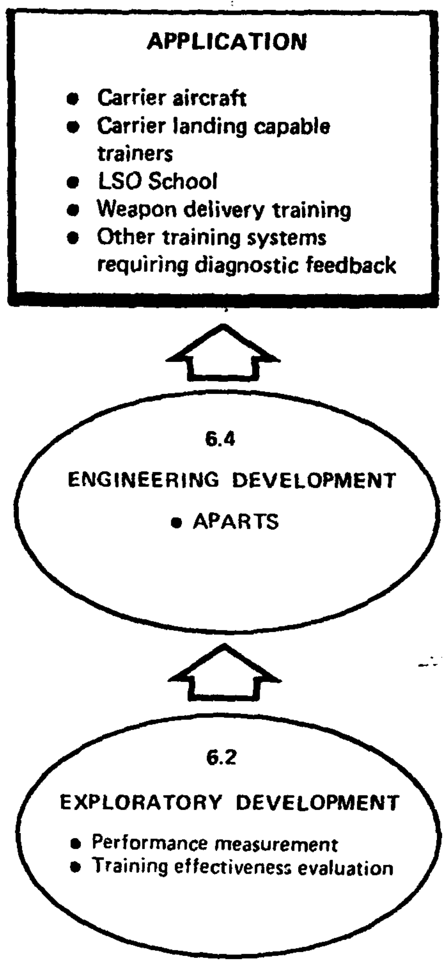
- Reduced instructor administrative and diagnostic workload.
- A data base of normative landing problems for instructor use.
- A data base for LSO orientation in LSO School.

In addition to LSO and pilot training, APARTS methodology has potential application to other structured training scenarios such as weapons delivery training, which involve voluminous amounts of performance data and analysis.

Research and Development Notes

The responsible researcher on this project was LCDR Larry Frank, USN, Naval Training Equipment Center (Code N-712), Orlando, FL, 32813, (305) 646-5130. Contractor support was provided by Dunlap and Associates West, Inc., 920 Kline Street, Suite 203, La Jolla, CA, 92037. The project was funded in Program Element 62757N, Human Factors and Simulation Technology, Subproject WF45-526, Training Devices and Simulation. Further effort is anticipated in Engineering Development. Work was initiated in June 1981 and this Exploratory Development will be completed in February 1984. There have been several Technical Reports and Papers. Two of the more recent are: Breidenback, S. T. and Brictson, C. A., *Field Demonstration of the Automated Performance Assessment and Remedial Training System* (APARTS), NAVTRAEQUIPCEN 80-D-0011-0023-1, in press; and Breidenback, S. T. and Brictson, C. A., *Development of the Automated Performance Assessment and Remedial Training System (APARTS): A Landing Signal Officer Training Aid*, NAVTRAEQUIPCEN 79-D-0105-1, June, 1981.

Program dynamics are:



INDEX TO PREVIOUS ANNUAL REPORTS

Because there have been five previous annual reports, it is becoming increasingly possible to engage in a retrospective overview of the programs which have been and are being implemented. This Index provides such an overview.

MANPOWER AND PERSONNEL

HUMAN FACTORS ENGINEERING (Continued)

SIMULATION AND TRAINING DEVICES

REPORT DOCUMENTATION PAGE

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Human Factors Engineering	Education	Training Devices
Manpower	Training	Utilization

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This is the sixth annual report of the utilization of people-related Navy RDT&E. It includes examples of both utilization and technology base advancement, primarily from FY 1982. The examples are organized within four technical areas: Manpower and Personnel, Education and Training, Human Factors Engineering, and Simulation and Training Devices. Each example is discussed in terms of need, approach and results, utilization, impact, and research and development notes.

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